Federal Aviation Administration – Regulations and Policies
Aviation Rulemaking Advisory Committee

Transport Airplane and Engine Issue Area
Seat Testing Harmonization Working Group
Task 1 – Certification of Flightcrew Seats

Task Assignment

Aviation Rulemaking Advisory Committee; Transport Airplane and Engine Subcommittee; Hydraulic Test Harmonization Working Group

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of establishment of hydraulic test harmonization working group.

SUMMARY: Notice is given of the establishment of the Hydraulic Test Harmonization Working Group of the Transport Airplane and Engine Subcommittee. This notice informs the public of the activities of the Transport Airplane and Engine Subcommittee of the Aviation Rulemaking Advisory Committee.

FOR FURTHER INFORMATION CONTACT: Mr. William J. (Joe) Sullivan, Executive Director, Transport Airplane and Engine Subcommittee, Aircraft Certification Service (AIR-3), 800 Independence Avenue, SW., Washington, DC 20591, Telephone: (202) 267-9554; FAX: (202) 267-5364.

SUPPLEMENTARY INFORMATION: Federal Aviation Administration (FAA) established an Aviation Rulemaking Advisory Committee (56 FR 2190, January 22, 1991) which held its first meeting on May 23, 1991 (56 FR 20492, May 3, 1991). The Transport Airplane and Engine Subcommittee was established at that meeting to provide advice and recommendations to the Director, Aircraft Certification Service, FAA, regarding the airworthiness standards for transport airplanes, engines and propellers in parts 25, 33 and 35 of the Federal Aviation Regulations (14 CFR parts 25, 33 and 35).

The FAA announced at the Joint Aviation Authorities (JAA)—Federal Aviation Administration (FAA) Harmonization Conference in Toronto, Ontario, Canada, (June 2–5, 1992) that it would consolidate within the Aviation Rulemaking Advisory Committee structure an ongoing objective to "harmonize" the Joint Aviation Requirement (JAR) and the Federal Aviation Regulations (FAR). Coincident with that announcement, the FAA assigned to the Transport Airplane and Engine Subcommittee those projects related to JAR/FAR 25, 33 and 35 harmonization which were then in the process of being coordinated between the JAA and the FAA. The harmonization process included the intention to present the results of JAA/FAA coordination to the public in the form of either a Notice of Proposed Rulemaking or an advisory circular—an objective comparable to and compatible with that assigned to the Aviation Rulemaking Advisory Committee. The Transport Airplane and Engine Subcommittee, consequently, established the Hydraulic Test Harmonization Working Group.

Specifically, the Working Group's task is the following:

The Hydraulic Test Harmonization Working Group is charged with making recommendations to the Transport Airplane and Engine Subcommittee concerning the FAA disposition of the following subject recently coordinated between the JAA and the FAA:

Hydraulic Systems and Test Conditions: Make recommendations concerning new or revised requirements for hydraulic systems and the associated test conditions for hydraulic systems installed in transport category airplanes (FAR 25.1435).

Reports:

A. Recommend time line(s) for completion of the task, including rationale, for Subcommittee consideration at the meeting of the subcommittee held following publication of this notice.

B. Give a detailed conceptual presentation on each task to the Subcommittee before proceeding with the work stated under items C, below.

C. Draft a Notice of Proposed Rulemaking the task proposing new or revised requirements, a supporting economic analysis, and other required analysis, with any other collateral documents (such as Advisory Circulars) the Working Group determines to be needed.

D. Give a status report on each task at each meeting of the Subcommittee.

The Hydraulic Test Harmonization Working Group will be comprised of experts from those organizations having an interest in the tasks assigned. A Working Group member need not necessarily be a representative of one of the organizations of the parent Transport Airplane and Engine Subcommittee or of the full Aviation Rulemaking Advisory Committee. An individual who has expertise in the subject matter and wishes to become a member of the Working Group should write the person listed under the caption **FOR FURTHER INFORMATION CONTACT** expressing that desire, describing his or her interest in the task, and the expertise he or she would bring to the Working Group. The request will be reviewed with the Subcommittee and Working Group Chairs and the individual will be advised whether or not the request can be accommodated.

The Secretary of Transportation has determined that the information and use of the Aviation Rulemaking Advisory Committee and its subcommittees are necessary in the public interest in connection with the performance of duties of the FAA by law. Meetings of the full Committee and any subcommittees will be open to the public except as authorized by section 10(d) of the Federal Advisory Committee Act. Meetings of the Hydraulic Test Harmonization Working Group will not be open to the public except to the extent that individuals with an interest and expertise are selected to participate. No public announcement of Working Group meetings will be made.

Issued in Washington, DC, on December 4, 1992.

William J. Sullivan,

Executive Director, Transport Airplane and Engine Subcommittee, Aviation Rulemaking Advisory Committee.

[FR Doc. 92-30116 Filed 12-10-92; 8:45 am]

BILLING CODE 4910-13-M

Recommendation Letter

Gerald R. Mack
Director
Airplane Certification

Boeing Commercial Airplane Group
P.O. Box 3707, #MS 67-UM
Seattle, WA 98124-2207

ARM-20

ARM

October 27, 1995
B-T000-ARAC-95-007

Mr. Anthony J. Broderick
Associate Administrator for Regulations and Certification, (AVR-1)
Department of Transportation
Federal Aviation Administration
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BOEING

Dear Mr. Broderick:

The Aviation Rulemaking Advisory Committee's Transport Airplane and Engine Issues Group (TAEIG) met in Boston, Massachusetts on October 17 and 18, 1995. One of the significant items for consideration and recommended action was the draft Advisory Circular 25.562-1 on Seat Dynamic Testing. The TAEIG's Seat Test Working Group was tasked to clarify and harmonize the A.C. guidance.

The Working Group had numerous meetings before reaching an agreement. Part of their problem for the extended time period to bring the draft A.C. to the TAEIG was the current difficulty being experienced in TSO C-127 approval and FAR 25.562 installation certification. The Working Group was well aware of the peripheral issues for which a public meeting was held on October 23 and 24, 1995.

After considerable discussion at the Boston meeting, the TAEIG recommends that the draft A.C. be processed. This TAEIG agreement for recommendation was based on the provision that it be understood the A.C. reflects only the action chartered to ARAC and that it does not signify industry's satisfaction with the rule.

In consideration of the October 23 and 24 Public meeting, TAEIG strongly requests that any tasks that evolve from the meeting, in terms of guidance and/or rule change, be given to the TAEIG. Also, it is requested that if the A.C. is subsequently modified by the FAA prior to publication without the concurrence of TAEIG, the final publication not be identified as an ARAC product.

BOEING

Sincerely,

G. R. Mack

Gerald R. Mack
Assistant Chairman
Transport Airplane & Engine Issues Group
Aviation Rulemaking Advisory Committee
Tele: (206) 234-9570, Fax: 237-0192, Mailstop: 67-UM

Enclosure

Acknowledgement Letter

U.S. Department
of Transportation

**Federal Aviation
Administration**

800 Independence Ave., S.W.
Washington, D.C. 20591

DEC 20 1995

Mr. Gerald R. Mack
Aviation Rulemaking Advisory Committee
Boeing Commercial Airplane Group
P.O. Box 3707, M/S 67-UM
Seattle, WA 98124-2207

Dear Mr. Mack:

Thank you for your October 27 letter forwarding the Aviation Rulemaking Advisory Committee's (ARAC) recommendation in the form of a draft Advisory Circular (AC) on Seat Dynamic Testing.

You stated that the recommendation reflects only the action that was chartered to ARAC; and that it does not signify industry's satisfaction with the rule. ARAC's position in this regard is noted. You also asked that any tasks involving a possible rule change or guidance on this issue, that evolve from the October 23 and 24 public meeting in Seattle, be given to ARAC, Transport Airplane and Engine issues. This request will be considered. With regard to the request not to identify ARAC products, that have been subsequently changed by the Federal Aviation Administration (FAA), as ARAC products, it is necessary that we accurately describe in our documents how we arrived at the proposed or final product; and this means citing the work done by ARAC. However, we understand your concern, and will be careful to show how the ARAC product was altered by the FAA.

I am aware that the ARAC vote on this recommendation included two dissenting votes. We have asked the organizations involved to provide us additional information so we can address their concerns in the public notice on this AC.

I would like to thank the aviation community, and particularly the Seat Testing Harmonization Working Group, for its commitment to ARAC and for its interest and effort on this project.

Sincerely,

Anthony J. Broderick
Associate Administrator for
Regulation and Certification

Recommendation

U.S. Department of Transportation

Federal Aviation Administration

DRAFT

9-8-95

Advisory Circular

Subject: DYNAMIC EVALUATION OF SEAT RESTRAINT SYSTEMS & OCCUPANT PROTECTION ON TRANSPORT AIRPLANES

Date:

Initiated by: ANM-110

AC No: 25.562-1

Change:

1. PURPOSE. This advisory circular (AC) provides information and guidance regarding acceptable, but not the only, means of compliance with Part 25 of the Federal Aviation Regulations (FAR) applicable to dynamic testing of seats intended for use in transport category airplanes. The AC provides background and discussion of the reasoning behind the test procedures. It also describes the test facilities and equipment necessary to conduct the tests. Terms used in this AC, such as "shall" and "must" are used only in the sense of ensuring applicability of this particular method of compliance when the acceptable method of compliance described herein is used. While these guidelines are not mandatory, they are derived from extensive FAA and industry experience in determining compliance with the pertinent FAR. This advisory circular does not change, create any additional, authorize changes in, or permit deviations from, regulatory requirements.

2. RELATED REGULATIONS. Sections 25.562, 25.785, 25.787, and 25.789 of Part 25 of the Federal Aviation Regulations.

3. DISCUSSION.

a. Intent of Tests. The intent of the tests is to evaluate airplane seats, restraints, and related interior systems in order to demonstrate the structural strength and the ability of those systems to protect an occupant from injuries in a crash environment. For example, occupant injury potential, which is influenced, by head strike envelopes and seat pitch, should be assessed. This assessment will be essentially qualitative.

b. Standardized Test Procedures - Reason and Practicalities. The tests described are standardized procedures that are generally to be regarded as the minimum necessary to demonstrate compliance. Such standardized procedures ensure that, to the maximum extent possible, consistent results are achieved between different test facilities. These facilities may be of varying types, as described in paragraph 6. They will often not be under the direct control of the designer or manufacturer of the article under test, and they may be primarily dedicated to testing not related to the aerospace industry. For this reason many of the procedures and evaluations described are already accepted as standards by government and commercial test facilities and have been modified only as necessary for the specific testing of civil airplane systems.

c. Standardized Test Procedures - Relationship to Design Standards. As stated above, the tests are, of necessity, standardized. The most obvious examples are the one size and weight representation of the occupant and the two discrete directions specified for the test impact. This philosophy is no different than that applied to static testing but, in the dynamic case, results in a much more complex consideration of the design factors involved in ensuring that the testing performed is adequate to demonstrate compliance with the applicable regulations.

(1) Occupant size. The dynamic tests are performed with an anthropomorphic test device (ATD) approximately representing the 50th percentile male occupant. Although the basic structural capability of the seat/restraint system is not directly demonstrated for other size occupants, aspects such as energy absorbing systems, restraint system loads and anchorage locations, and seat adjustments are typical design factors which are directly influenced by occupant size.

(2) Test Conditions. Only the two minimum impact tests are described in the dynamic test procedures discussed in this AC. These procedures therefore address the tests required to demonstrate compliance for one seat and restraint system installation. A typical use of a seat model on a particular aircraft will involve variations of seat design and installation. Additional tests may be necessary to demonstrate compliance for these variations if analysis is not adequate. An example is the lateral component of the test where it is necessary to consider the effect of loads from either side.

(3) Floor Deformation. The test procedure requires that for structural evaluation the floor should be deformed. The seat and restraint system should also perform properly if the floor remains undeformed.

(4) Head Impact. Occupant head impact with the interior of the airplane, should it occur, is evaluated by using a Head Injury Criterion (HIC) that can be measured directly in the tests described in this AC, or in alternative tests of the interior. The HIC is measured on the most critical surface within the ±10 degrees yaw envelope (measurement of the HIC does not supersede the requirements of § 25.785). The HIC does not consider injuries that can occur at low impact velocities from contact with surfaces having small contact areas or sharp edges, especially if those surfaces are relatively rigid.

(5) Femur Injury. Extensive seat testing has shown that the femur loading criterion is not exceeded. For this reason, the femur loads need not be recorded in the individual test if compliance can be shown by rational comparative analysis using data from previous tests.

NOTE: There may be several other aspects of the standardized test procedure that need to be considered when determining the test program required to demonstrate compliance or interpret the test results. The extent of the test program will depend on the most critical case determination and its applicability to other configurations. Further information on this aspect of testing is provided in paragraph 4b.

4. TEST CONDITIONS.

a. General. A minimum of two dynamic tests are required to assess the performance of an airplane seat, restraints, and related interior system. The seat, the restraint, and the nearby interior are all considered to act together as a system to provide protection to the occupant during a crash. For side-facing seats, there may be additional criteria necessary to determine that these seats provide the same level of safety as is intended by the regulation. (See paragraph 9d for additional considerations regarding side- facing seats.)

(1) Test 1 (Figure 1), as a single row seat test, determines the performance of the system in a test condition where the predominant impact force component is along the spinal column of the occupant, in combination with a forward impact force component. This test evaluates the structural adequacy of the seat, critical pelvic/lumbar column forces, and permanent deformation of the structure under downward and forward combined impact loading, and may yield data on ATD head displacement, velocity, and acceleration time histories.

(2) Test 2 (Figure 1), as a single row seat test, determines the performance of a system in a test condition where the predominant impact force component is along the longitudinal axis of the airplane and is combined with a lateral impact force component. This test evaluates the structural adequacy of the seat, permanent deformation of the structure, and the pelvic restraint and upper torso restraint (if applicable) behavior and loads, and may yield data on ATD head displacement, velocity, and acceleration time histories, and the seat leg loads imposed on the seat tracks or attachment fittings.

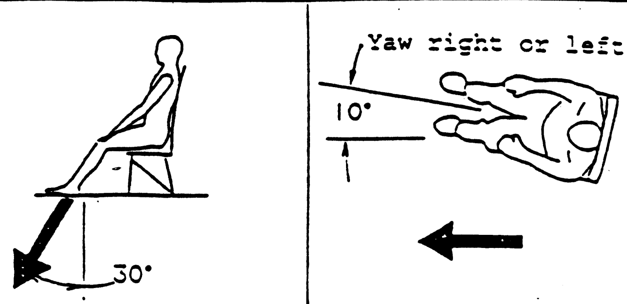
This test requires simulating airplane floor deformation by deforming the test fixture, as respectively prescribed in Figures 1 and 2 for single occupant and multiple occupant seats, prior to applying the dynamic impact conditions. The purpose of providing floor deformation for the test is to demonstrate that the seat/restraint system will remain attached to the airframe and perform properly, even though the airplane and/or seat are deformed by the forces associated with a crash.

(3) For seats placed in repetitive rows, an additional test condition, using two seats in tandem placed at representative fore and aft distance between the seats (seat pitch), similar to Test 2 with or without the floor deformation directly evaluates head and femur injury criteria (the floor deformation is required if the test also demonstrates structural performance). These injury criteria are dependent on seat pitch, seat occupancy, and the effect of hard structures within the path of head

excursions in the ±10 degrees yaw attitude range of the Test 2 conditions. The test procedure using the appropriate data obtained from Test 2, as described in paragraph 12d, may be an alternative to multiple row testing.

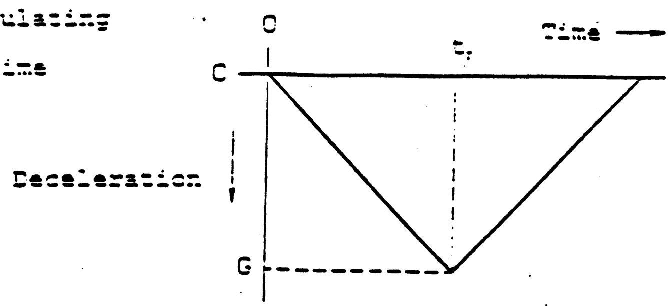
NOTE: It may be possible to evaluate the HIC using alternative tests. Specific methodologies will require acceptance for certification.

	TEST 1	TEST 2
Illustration shows a forward-facing seat Inertial load shown by arrow		



	TEST 1	TEST 2
Min V_i m/s (ft/s)	10.67 (35)	13.41 (44)
Max t_r s	0.08	0.09
Min G.	14	16
Deform floor:		
Degrees roll	0	10
Degrees pitch	0	10

Test Pulse Simulating Aircraft Floor Deceleration-Time History:



t_r = Rise time
V_i = Impact velocity

Figure 1. Type A Seat/Restraint System Dynamic Tests

b. Consideration of test criteria. The tests should be planned to achieve "most critical" conditions for the criteria that make up each test.

(1) For multiple place seats, a rational structural analysis shall be used to determine the number and seat location for the ATDs and the direction for seat yaw in Test 2 to provide the most critical seat structural test. This will usually result in unequally loaded seat legs. The floor deformation procedure shall be selected to increase the load on the highest loaded seat leg and to load the floor track or fitting in the most severe manner.

(2) If multiple-row testing is used to gather data to assess head and femur injury protection in passenger seats, the seat pitch shall be selected so that the head would be most likely to contact hard structure in the forward seat row. The effect of the 10 degree yaw in Test 2, the seat back breakover, and front seat occupancy shall be considered. Results from previous tests or rational analysis may be used to estimate the head strike path of similar seats in similar installations. The front row may be unoccupied.

(3) If non-symmetrical upper torso restraints (such as single diagonal shoulder belts) are used in a system, they shall be installed on the test fixture in a position representative of that in the airplane and which would most likely allow the ATD to move out of the restraint. For example, in a forward-facing crew seat equipped with a single diagonal shoulder belt, the seat should be yawed in Test 2 in a direction such that the belt passes over the trailing shoulder.

(4) If a seat has vertical or horizontal adjustments, it shall be tested in the position that produces the most critical loads on the seat structure (typically the highest vertical position). Positions prohibited for takeoff and landing need not be considered. Seat adjustments that do not have a significant effect on structural loading (e.g., thigh support angle, lumbar support, armrest and headrest positions) shall be tested in the design positions for the 50th-percentile male occupant, unless special requirements dictate the positions allowed for takeoff and landing.

5. TEST ARTICLES.

a. General. In all cases, the test article must be representative of the final production article in all structural elements, and shall include the seat cushions, restraints, and armrests. It must also include a functioning position adjustment mechanism and correctly adjusted breakover (if present). Food trays or any other service or accouterment that are part of the seat design must be representative of the final production item if they influence seat stiffness or head impact. Otherwise they and any other items of mass that are carried on or positioned by the seat structure e.g., weights simulating luggage carried by luggage restraint bars [90 N (20 lb) per passenger place], fire extinguishers, survival equipment, emergency equipment etc.

need only be representative masses. If these items of mass are placed in a position that could limit the function of an energy-absorbing feature in the test article, they should be of representative shape and stiffness, as well as weight. In addition, items of mass of any significance could become both an evacuation hazard, as well as dangerous projectiles. Nonetheless, detachment of certain items, such as an in-arm ashtray or decorative trim, can be considered inconsequential and should not be grounds for re-test (the means of restraint should be improved, however). In any case, the separation of an item of mass should not leave any sharp or injurious edges. Function of equipment or systems after the test is not required. Once an item of mass has been demonstrated to be retained in its critical loading case, subsequent tests may be conducted with the item secured for test purposes. This AC does not establish operational requirements for equipment attached to the seat system.

b. Selection of test articles. Many designs comprise a family of seats that have the same basic structural design but differ in detail. For example, a basic seat frame configuration can allow for several different seat leg locations to permit installation in different airplanes. If these differences are of a nature that their effect can be determined by rational analysis, then the analysis can determine the most critical configuration. As a minimum, the most highly stressed configuration shall be selected for the dynamic tests so that the other configurations could be accepted by comparison with that configuration. For Test 2, there are two factors that need to be considered in selecting the critical structural test configurations. First, the seat to airplane interface loads (undeformed seat) can be determined by rational analysis for all seat design and load configurations. The rational analysis can be based on static or dynamic seat/occupant analytical methods. That rational analysis can form the basis for selecting the most highly stressed critical configuration based on load. Additionally, the effects of seat deformation should also be considered. As noted, a family of seats typically includes seat models with varied seat leg locations. The effects of floor deformation are more critical for narrow spaced seat legs. Thus, a test or rational analysis of the seat model with the minimum seat leg spacing needs to be conducted to evaluate the most highly stressed critical configuration based on deformation.

The following additional items shall be considered in choosing test articles and the manner of loading:

(1) If a multiple-place seat incorporates energy-absorbing or load-limiting features that are necessary to meet the test criteria or other requirements, a partially occupied seat may adversely affect the performance of that seat. In such a case it shall be shown, by rational analysis or additional testing, that the seat will continue to perform as intended, even with fewer occupants.

(2) If different configurations of the same basic design incorporate load-carrying members, especially joints or fasteners, that differ in detail design, the performance of each detail design should be demonstrated in a dynamic test. Experience has shown that small details in the design often cause problems in meeting the test performance criteria.

(3) Additional dynamic impact testing may be required for a seat with features that could affect its performance, even though the test may not be the most critical case based on structural performance. For example, if in one of the design configurations the restraint system attachment points are located so that the pelvic restraint is more likely to slip above the ATD's pelvis during the impact, that configuration should also be dynamically tested, even though the structural loading might be less than the critical configuration in a family of seats.

(4) Typical dress cover materials, including synthetic and natural fabrics, and leather, can be used on a seat without testing more than one material, or substituted on an already certificated seat. Evaluation of such materials has shown the effect on test results is small, particularly considering other factors such as occupant clothing. It is possible that some unusual seat surfaces such as hard plastics, which exhibit very low friction coefficients, may require some additional substantiation.

6. TEST FACILITIES.

a. General. There are a number of test facilities that can be used to accomplish dynamic testing. These can be grouped into categories based on the method used to generate the impact pulse (i.e., accelerators, decelerators, or impact with rebound), and whether the facility is a horizontal (sled) design or a vertical (droptower) arrangement. Each of the designs has characteristics that have advantages or disadvantages with regard to the dynamic tests discussed in this AC. One concern is the rapid sequence of acceleration and deceleration that must take place in the tests. In an airplane crash, the acceleration phase is always gradual, and usually well separated in time from the deceleration (crash) phase. In a test, the deceleration always closely follows the acceleration. When assessing the utility of a facility for the specific test procedures outlined in the recommendations, it is necessary to understand the possible consequences of this rapid sequence of acceleration and deceleration.

b. Deceleration sled facilities. In an airplane crash, the impact takes place as a deceleration, so loads are applied more naturally in test facilities that create the test impact pulse as a deceleration. Since it is simpler to design test facilities to extract energy in a controlled manner than to impart energy in a controlled manner, several different deceleration sled facilities can be found. The deceleration sled facility at the Federal Aviation Administration's Civil Aeromedical Institute (CAMI) was used in developing the test procedures discussed in this AC. The acceleration phase of the test, where sufficient velocity for the test impact pulse is acquired, can distort the test results if the acceleration is so high that the test articles or ATDs are moved from their intended pre-test position. This inability to control the initial conditions of the test would directly affect the test results. This can be avoided by using a lower acceleration for a relatively long duration and by providing a coast phase (in which the acceleration or deceleration is almost zero) prior to the impact. This allows any dynamic oscillation in the test articles or the ATD, which might be caused by the acceleration, to decay. To guard against errors in data caused by pre-impact accelerations, data from the electronic test measurements (accelerations, loads) should be reviewed for the time period just before the test impact pulse to make sure all measurements are at the baseline (zero) level. Photometric film taken of the test should also be reviewed to make certain that the ATDs used in the test and the test articles were all in their proper position prior to the test impact pulse.

The horizontal test facility readily accommodates forward-facing seats in both tests discussed in this AC, but problems can exist in positioning the test ATDs in Test 1 if the seat is a rearward-facing or side- facing seat. In these cases, the ATDs tend to fall out of the seat due to the force of gravity and must be restrained in place using break-away tape, cords, or strings. Since each installation will present its own problems, there is no simple, generally applicable, guidance which can be given for doing this. Attention should be given to positioning the ATD against the seat back, and to proper positioning of the ATD's arms and legs. It will probably be necessary to build special supports for the break-away restraint so that they will not interfere with the function of the seat and restraint system during the test. Film taken of the test should be reviewed to make sure that the break-away restraint did break (or become slack) in a manner that did not influence the motion of the ATD or the test articles during the test.

c. Acceleration sled facilities. Acceleration sled facilities, usually based on the HYdraulically controlled Gas Energized (HYGE) accelerator device, provide the impact test pulse as a controlled acceleration at the beginning of the test. The test item and the ATDs are installed facing in the opposite direction from the velocity vector, (opposite from the direction used on a deceleration facility) to account for the change in direction of the impact. There should be no problem with the ATD or the test items being out of position due to pre-impact sled acceleration, since there is no sled movement prior to the impact test pulse. After the impact test pulse, when the sled is moving at the maximum test velocity, it must be safely brought to a stop. Most of the facilities of this design have limited track length available for deceleration, so that the deceleration levels can be relatively high and deceleration may begin immediately after the impact test pulse. Since the dynamic response of the system follows (in time) the impact test pulse, any sled deceleration that takes place during that response will affect the response and change the test results. The magnitude of change depends on the system being tested, so that no general "correction factor" can be specified. The affect can be minimized if the sled is allowed to coast, without significant deceleration, until the response is complete. If the seat or restraint system experiences a structural failure during the test pulse, the post-impact deceleration can increase the damage and perhaps result in failures of unrelated components. This will complicate the determination of the initial failure mode, and make product improvement more difficult. One other consideration is that the photometric film coverage of the response to impact test pulse must be accomplished when the sled is moving at near maximum velocity. On-board cameras or a series of track-side cameras are usually used to provide film coverage of the test. Since on-board cameras frequently use a wide angle lens placed close to the test items, it is necessary to account for the effects of distortion and parallax when analyzing the film. The acceleration sled facility faces the same problems in accommodating rearward facing or side-facing seats in Test 1 as the deceleration sled facility, and the corrective action is the same for both facilities.

d. Impact-with-rebound sled facilities. One other type of horizontal test facility used is the "impact-with-rebound" sled facility. On this facility, the impact takes place as the moving sled contacts a braking system, which stores the energy of the impact, and then returns the stored energy back to the sled, causing it to rebound in the opposite direction. This facility has the advantage over acceleration or deceleration facilities in that only one half of the required velocity for the impact would need to be generated by the facility (assuming 100 percent efficiency). Thus, the track length can be shortened and the method of generating velocity is simplified. The disadvantages of this facility combine the problems mentioned above for both acceleration facilities and deceleration facilities. Since one of the reasons for this type of facility is to allow short track length to be used, it may be difficult to obtain sufficiently low acceleration just before or after the impact pulse to resolve data error problems caused by significant pre-impact and post-impact accelerations.

e. Drop towers. Vertical test facilities can include both drop towers (decelerators) and vertical accelerators. Vertical accelerators that can produce the long duration/displacement impact pulse depicted in Figure 1 have not been generally available. However, drop towers are one of the easiest facilities to build and operate, and are frequently used. In these facilities, the pull of earth's gravity is used to accelerate the sled to impact velocity so that the need for a complex mechanical accelerating system is eliminated. Unfortunately, these facilities are difficult to use for conducting Test 2, particularly for typical forward-facing seats. In preparing for this test, the seat must be installed at an angle such that the ATD tends to fall from the seat due to gravity. The restraint system being tested cannot hold the ATD against the seat unless tightened excessively, and will not usually locate the head, arms, or legs in their proper position relative to the seat. Design and fabrication of an auxiliary "break-away" ATD positioning restraint system just for this test is a complex task. The auxiliary restraint must not only position the ATD against the seat (including maintaining proper seat cushion deflection) during the pre-release condition of 1g, it must also maintain the ATD in that proper position during the free fall to impact velocity when the system is exposed to 0g, and then it must release the ATD in a manner that does not interfere with the ATD response to impact. The usual sequence of 1g/0g impact, without the possibility of a useful "coast" phase, as done in horizontal facilities, causes shifts in initial conditions for the test impact pulse which can affect the response to the impact. The significance of this will depend on the dynamic characteristics of the system being tested, and these are seldom known with sufficient accuracy to enable the response to be corrected. In addition, the earth's gravity will oppose the final rebound of the ATDs into the seat back, so that an adequate test of seat back strength and support for the ATD cannot be obtained. The problems in Test 1, or with rear-facing seats in Test 2, are not as difficult because the seat will support the ATD occupant prior to the free fall. However, the 0g condition that exists prior to impact will allow the ATD to "float" in the seat restraint system, perhaps changing position and certainly changing the initial impact conditions. Again, use of an auxiliary break-away restraint system to correct these problems is difficult.

7. ANTHROPOMORPHIC TEST DEVICES.

a. General. The tests discussed in this AC were developed using modified forms of the ATDs specified by the United States Code of Federal Regulations, Title 49, Part 572 Anthropomorphic Test Dummies, Subpart B - 50th Percentile Male. These "Part 572B" ATDs have been shown to be reliable test devices that are capable of providing reproducible results in repeated testing. However, since ATD development is a continuing process, provision was made for using "equivalent" ATDs. ATD types should not be mixed when completing the tests discussed in this AC.

b. Modification to measure pelvic/lumbar load.

(1) To measure the axial compressive load between the pelvis and lumbar column due to vertical impact as well as downward loads caused by upper torso restraints, a load (force) transducer shall be inserted into the ATD pelvis just below the lumbar column. This modification is shown in Figure 2. The illustration shows a commercially available femur load cell, with end plates removed, that has been adapted to measure the compression load between the pelvis and the lumbar column of the ATD.

(2) A femur load cell is selected because of its availability in most test facilities and its ability to measure the compression forces without errors due to sensitivity to shear forces and bending or twisting moments which are also generated during the test. To maintain the correct seated height of the ATD the load cell must be fixed in a rigid cup which is inserted into a hole bored in the top surface of the ATD pelvis. The interior diameter of the cup provides clearance around the outside diameter of the load cell, so that the loads are transmitted only through the ends of the cell. If necessary, ballast shall be added to the pelvis to maintain the weight of the original (unmodified) assembly.

(3) Alternative approaches to measuring the axial force transmitted to the lumbar spinal column by the pelvis are acceptable if the method:

(i) Accurately measures the axial force but is insensitive to moments and forces other than that being measured;

(ii) Maintains the intended alignment of the spinal column and the pelvis, the correct seated height, and the correct weight distribution of the ATD; and

(iii) Does not alter the other performance characteristics of the ATD.

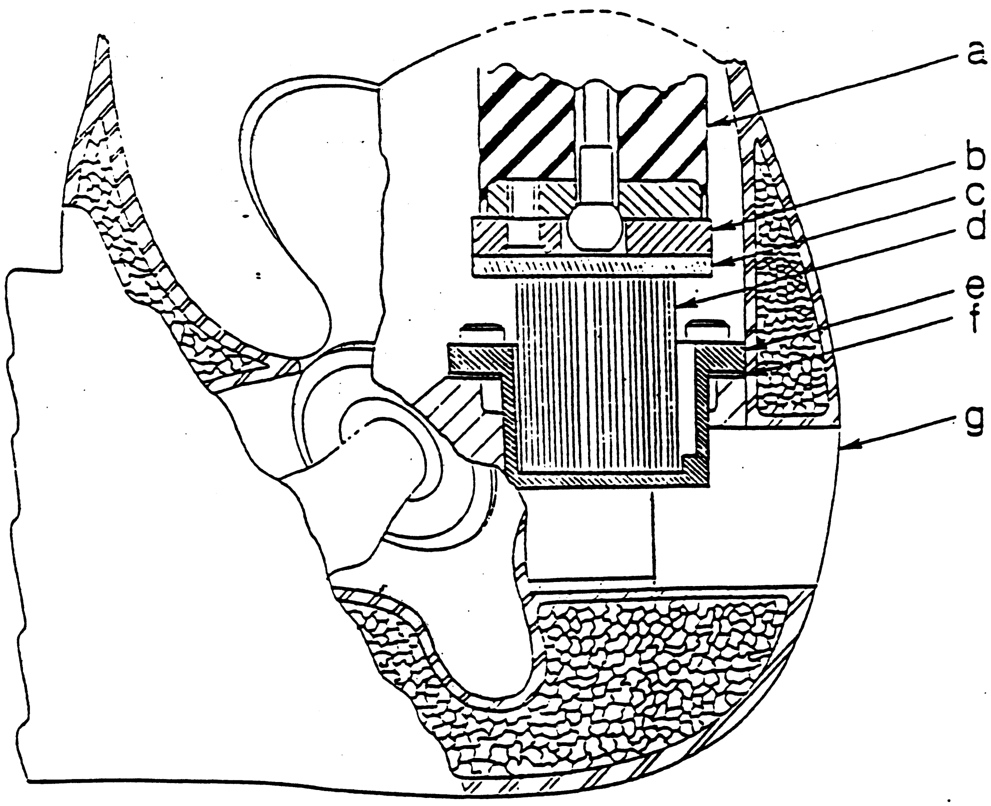


Figure 2. Installation of Pelvic–Lumbar Spine Load Cell in Part 572B ATD.

This illustration shows an acceptable adaptation of a femur load cell (d) at the base of the ATD lumbar spine (a). The load cell is in line with the centerline of the lumbar spine, and set below the top surface of the pelvis casting to maintain the seated height of the ATD. A rigid adapter cup (e) is fabricated to hold the load cell and a hole is bored in the ATD pelvis to accept the cup. Clearance must be provided between the walls of the adapter cup and the load cell for the wires leading from the cell. The bottom of the load cell is bolted to the adapter cup. Adapter plates having similar hold patterns in their periphery are fabricated for the lower surface of the lumbar spine (b) and the upper surface of the load cell (c). These plates are fastened to the lumbar spine and load cell with screws through holes matching threaded holes in those components, and are then joined together by bolts through the peripheral holes. The flange on the adapter cup has a bolt hole pattern that matches that on the pelvis. The cup is fastened to the pelvis using screws to the threaded holes in the pelvis. Spacers (f) may be placed under the flange of the cup to obtain the specified ATD seating height. Additional weight should be placed in the cavity below the adapter cup to compensate for any weight lost because of this modification. The instrument cavity plug (g) is cut to provide clearance for the adapter cup and added weight.

c. Other ATD Modifications.

(1) To prevent failure of the clavicle used in Part 572 Subpart B ATDs due to flailing, a clavicle of the same shape but of higher strength material can be substituted.

(2) Submarining indicators, such as electronic transducers, may be added on the ATD pelvis. These are located on the anterior surface of the ilium of the ATD pelvis without altering its contour, and indicate the position of the pelvic restraint as it applies loads to the pelvis. These indicators can provide a direct record that the pelvic restraint remains on the pelvis during the test, and eliminate the need for careful review of high-speed camera images to make that determination.

d. Equivalent ATDs. The continuing development of ATDs for dynamic testing of seating restraint/crash-injury-protection systems is guided by goals of improved biofidelity (human-like response to the impact environment) and reproducibility of test results. For the purposes of the tests discussed in this AC, these improved ATDs can be considered the equivalent of the Part 572B ATD if:

(1) They are fabricated in accordance with design and production specifications established and published by a regulatory agency that is responsible for crash injury protection systems;

(2) They are capable of providing data for the measurements discussed in this AC or of being readily altered to provide the data;

(3) They have been evaluated by comparison with the Part 572B ATD and are shown to generate similar response to the impact environment discussed in this AC; and

(4) Any deviations from the Part 572B ATD configuration or performance are representative of the occupant of a civil airplane in the impact environment discussed in this AC.

8. INSTRUMENTATION.

a. General.

(1) Electronic and photographic instrumentation systems shall be used to record data for qualification of seats. Electronic instrumentation shall measure the test environment, and measure and record data required for comparison of performance to pass/fail criteria.

(2) Photographic instrumentation shall be used to document the overall results of tests, confirming that the pelvic restraint remains on the ATD's pelvis, and that the upper torso restraint straps remain on the ATD's shoulder during impact,

and documenting that the seat does not deform as a result of the test in a manner that would impede rapid evacuation of the airplane by the occupants and that the seat remains attached at all points of attachment. For passenger seats with lap belt angles of btween 45 and 55 degrees, submarining is typically not a problem. For this reason, a second camera (e.g., an overhead camera) for evaluation of submarining is not necessary.

b. Electronic Instrumentation. Electronic instrumentation should be accomplished in accordance with the Society of Automotive Engineers Recommended Practice SAE J211, "Instrumentation for Impact Tests." In this practice, a data channel is considered to include all of the instrumentation components from the transducer through the final data measurement, including connecting cables and any analytical procedures that could alter the magnitude or frequency content of the data. Each dynamic data channel is assigned a nominal channel class that is equivalent to the high frequency limit for that channel, based on a constant output/input ratio versus frequency response plot which begins at 0.1 Hz (+1/2 to -1/2 dB) and extends to the high frequency limit (+1/2 to -1 dB). Frequency response characteristics beyond this high frequency limit are also specified. When digitizing data, the sample rate should be at least five times the -3 dB cutoff frequency of the presample analog filters. Since most facilities set all presample analog filters for Channel Class 1000, and since the -3 dB cutoff frequency for channel class 1000 is 1650 Hz, the minimum digital sampling rate would be about 8000 samples per second. For the dynamic tests discussed in this AC, the dynamic data channels shall comply with the following channel class characteristics:

(1) Sled or drop tower vehicle acceleration should be measured in accordance with the requirements of Channel Class 60, unless the acceleration is also integrated to obtain velocity or displacement, in which case it shall be measured in accordance with Channel Class 180 requirements.

(2) Belt-restraint system and seat attachment reaction loads (when measured) shall be measured in accordance with the requirements of Channel Class 60. Loads in restraint systems that attach directly to the test fixture can be measured by three-axis load cells fixed to the test fixture at the appropriate location. These commercially available load cells measure the forces in three orthogonal directions simultaneously, so that the direction as well as the magnitude of the force can be determined. If desired, similar load cells can be used to measure forces at other boundaries between the test fixture and the test item, such as the forces transmitted by the legs of the seat into the floor track. It is possible to use independent, single axis load cells arranged to provide similar data, but care should be taken to use load cells that can withstand significant cross axis loading or bending without causing errors in the test data.

(3) ATD head accelerations used for calculating the Head Injury Criterion (HIC) should be measured in accordance with the requirements of Channel Class 1000.

(4) ATD femur forces should be measured in accordance with Channel Class 600.

(5) ATD pelvic/lumbar column force shall be measured in accordance with the requirements of Channel Class 600.

(6) The full-scale calibration range for each channel shall provide sufficient dynamic range for the data being measured.

(7) Digital conversion of analog data shall provide sample resolution of not less than 1 percent of full-scale input.

c. Photographic Instrumentation. Photographic instrumentation shall be used for documenting the response of the ATDs and the test items to the dynamic test environment. Both high-speed and still image systems should be used.

(1) High speed cameras that provide data used to calculate displacement or velocity shall operate at a nominal speed of 500 frames per second. Photo instrumentation methods shall not be used for measurement of acceleration. The locations of the cameras and of targets or targeted measuring points within the field of view shall be measured and documented. Targets shall be at least 1/100 of the field width covered by the camera and shall be of contrasting colors or shall contrast with their background. The center of the target shall be easily discernible. Rectilinearity of the image shall be documented. If the image is not rectilinear, appropriate correction factors shall be used in the data analysis process. Photographic instrumentation should be in accordance with SAE J211, part 2.

(2) A description of photographic calibration boards or scales within the camera field of view, the camera lens focal length, and the make and model of each camera and lens shall be documented for each test. Appropriate digital or serial timing shall be provided on the image media. A description of the timing signal, the offset of timing signal to the image, and the means of correlating the time of the image with the time of electronic data shall be provided. A rigorous, verified analytical procedure shall be used for data analysis.

(3) Cameras operating at a nominal rate of 200 frames per second or greater may be used to document the response of ATDs and test items if measurements are not required. For example, actions such as movement of the pelvic restraint system webbing off of the ATD's pelvis can be observed by documentation cameras placed to obtain a "best view" of the anticipated event. These cameras shall be provided with appropriate timing and a means of correlating the image with the time of electronic data.

(4) Still image cameras shall be used to document the pre-test installation and the post-test response of the ATDs and the test items. At least four

pictures shall be obtained from different positions around the test items in pre-test and post-test conditions. Where an upper torso restraint system is installed, post-test pictures shall be obtained before moving the ATD. For additional post-test pictures, the ATD's upper torso may be rotated to its approximate upright seated position so that the condition of the restraint systems may be better documented, but no other change to the post-test response of the test item or the ATD shall be made. The pictures shall document whether the seat remained attached at all points of attachment to the test fixture.

(5) Still pictures may also be used to document post-test yielding of the seat for the purpose of showing that it would not impede the rapid evacuation of the aircraft occupants. The ATD should be removed from the seat in preparation for still pictures used for that purpose. Targets or an appropriate target grid should be included in such pictures, and the views should be selected so that potential interference with the evacuation process can be determined. For tests where the ATD's head impacts a fixture or another seat back, pictures shall be taken to document the head contact areas.

9. <u>TEST FIXTURES</u>.

a. <u>General</u>. A test fixture is required to position the test article on the sled or drop carriage of the test facility and takes the place of the airplane's floor structure. It does not need to simulate the airplane floor flexibility. It holds the attachment fittings or floor tracks for the seat and provides the floor deformation if needed for the test; it provides anchorage points if necessary for the restraint system; it provides a floor or footrest for the ATD; and it positions instrument panels, bulkheads, or a second row of seats, if required.

b. <u>Floor Deformation</u>.

(1) <u>Purpose of floor deformation</u>. The purpose of providing floor deformation for the longitudinal tests is to demonstrate that the seat system will remain attached and perform properly, even though the seat or airframe may be deformed by the forces associated with the crash. Floor deformation is not required for demonstrating compliance with injury criteria.

(2) <u>Floor Deformation Fixture</u>. For the typical seat with four seat legs mounted in the aircraft on two parallel tracks, the floor deformation test fixture shall consist of two parallel beams: a pitch beam that pivots about a lateral (y) axis and a roll beam that pivots about a longitudinal (x) axis (see Figure 3 for a schematic representation). The beams can be made of any rigid structural form: box, I-beam, channel, or other appropriate cross section. The pitch beam shall be capable of rotating in the x-z plane up to ±10 degrees relative to the longitudinal (x) axis. The roll beam should be capable of ±10 degrees roll about the centerline of floor tracks or fittings. A means shall be provided to fasten the beams in the deformed positions.

The beams should have provision for installing floor track or other attachment fittings on their upper surface in a manner that does not alter the above-floor strength of the track or fitting. The track or other attachment fittings must be representative in above-floor configuration and strength to that which would be used in the airplane. Structural elements below the surface of the floor that are not considered part of the floor track or seat attach fitting need not be included in the installation. Appropriate safety precautions should be taken while imposing floor deformations.

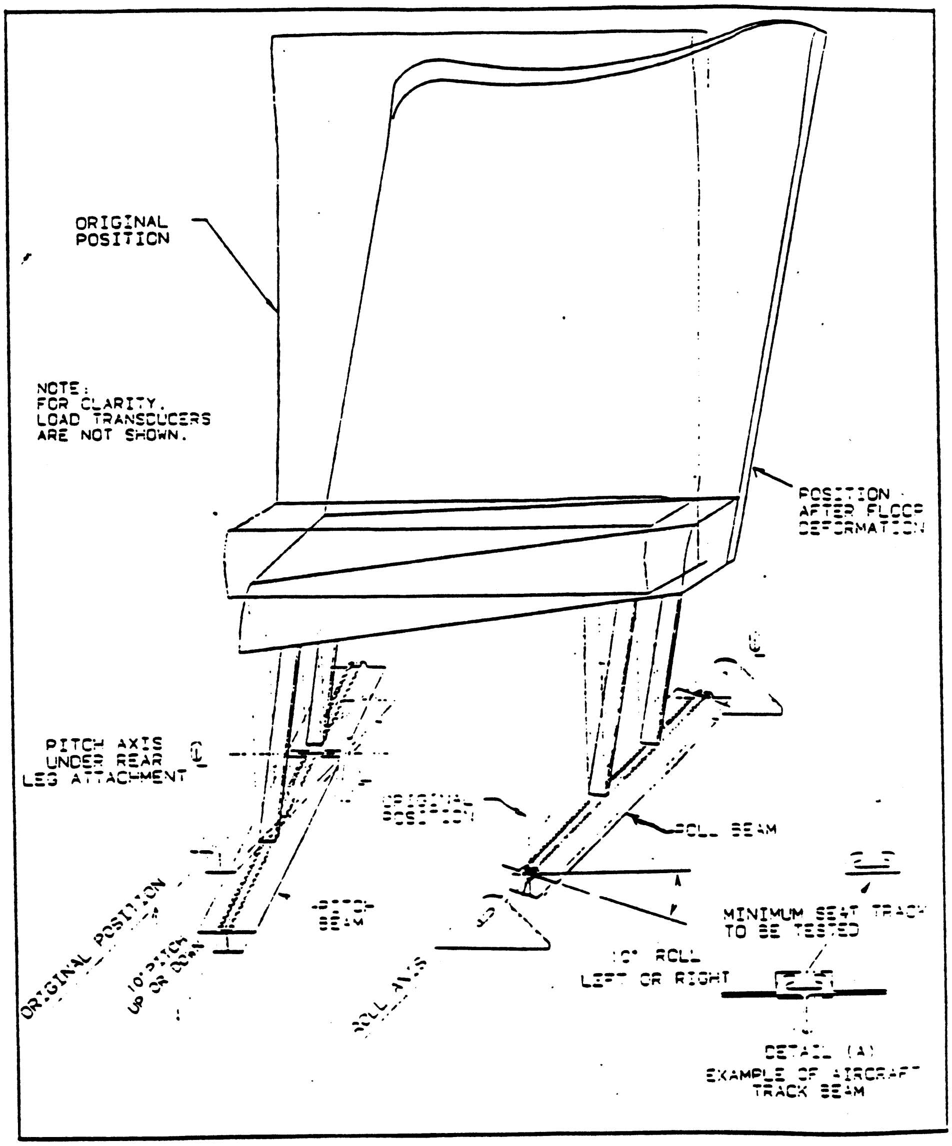


Figure 3.
Schematic Floor Deformation Fixture; Seat Legs Attached at Floor Level

(3) Airplane Floor Track or Attachment Fitting Simulation. An example of the minimum required representation of a floor track is shown in Detail A of Figure 3 for one type of seat track. The track, or other attachment fittings, must be representative of those used in the airplane. Alternatively, three components of reaction forces and three components of reaction moments may be measured during dynamic tests. These six components may be applied simultaneously, by a separate static or dynamic test, to a track or attachment fitting used on an airplane, or to a more critical track or attachment fitting than that used on an airplane, to demonstrate that the loads measured in the dynamic impact test will not fail the track or attachment fitting used on an airplane.

(4) Load Transducer Installation (Optional). The pitch and roll beams should have provisions for installing individual load transducers at each seat leg attachment point capable of measuring three reaction forces and, if necessary, three reaction moments (see paragraph 9b(3)). The load transducers should have provisions to install floor track or other attachment fittings on their upper surface in a manner that does not alter the above-floor strength of the track or fitting.

c. Other Mounting Configuration Constraints. The preceding discussion describes the fixture and floor deformation procedure that would be used for a typical seat that uses four seat legs and four attachments to the aircraft floor. These test procedures are not intended to be restricted only to those seat configurations, but shall be adapted to seats having other designs. Special test fixtures may be necessary for those different configurations. The following methods, while not covering all possible seat designs, shall be followed for the more common alternatives:

(1) Airplane seats with three legs may have one central leg at the front or back of the seat, and one leg on each side of the seat. The central leg shall be held in its undeformed position as deformation is applied to the side legs.

(2) Seats that have more than two pairs of legs should be tested with the floor warpage condition that results in the most critically stressed condition. This typically involves warping adjacent pairs of legs. Seats that employ several pairs of legs, ganged together by common cross tubes, can be distorted so that one pair (the critical pair) of legs is rolled, while the remaining legs on one side of the critical leg are pitched in unison. The legs that are pitched should be selected to increase the load on the critical leg, and stress the floor or track fitting in the most severe manner (see Figures 4 and 5).

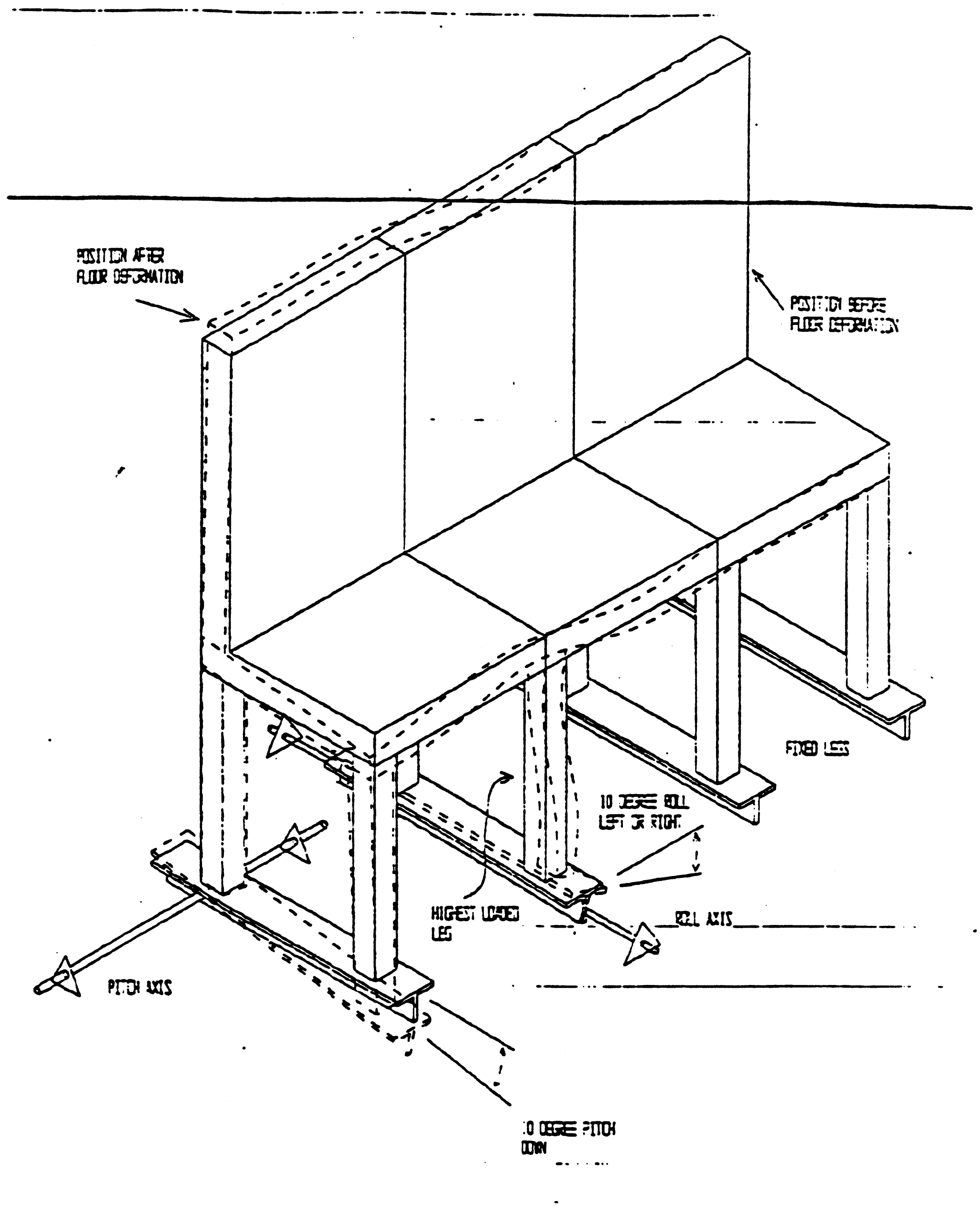

POSITION AFTER
FLOOR DEFORMATION
POSITION BEFORE
FLOOR DEFORMATION
FIXED LEGS
10 DEGREE ROLL
LEFT OR RIGHT
HIGHEST LOADED
LEG
ROLL AXIS
PITCH AXIS
10 DEGREE PITCH
DOWN

Figure 4.

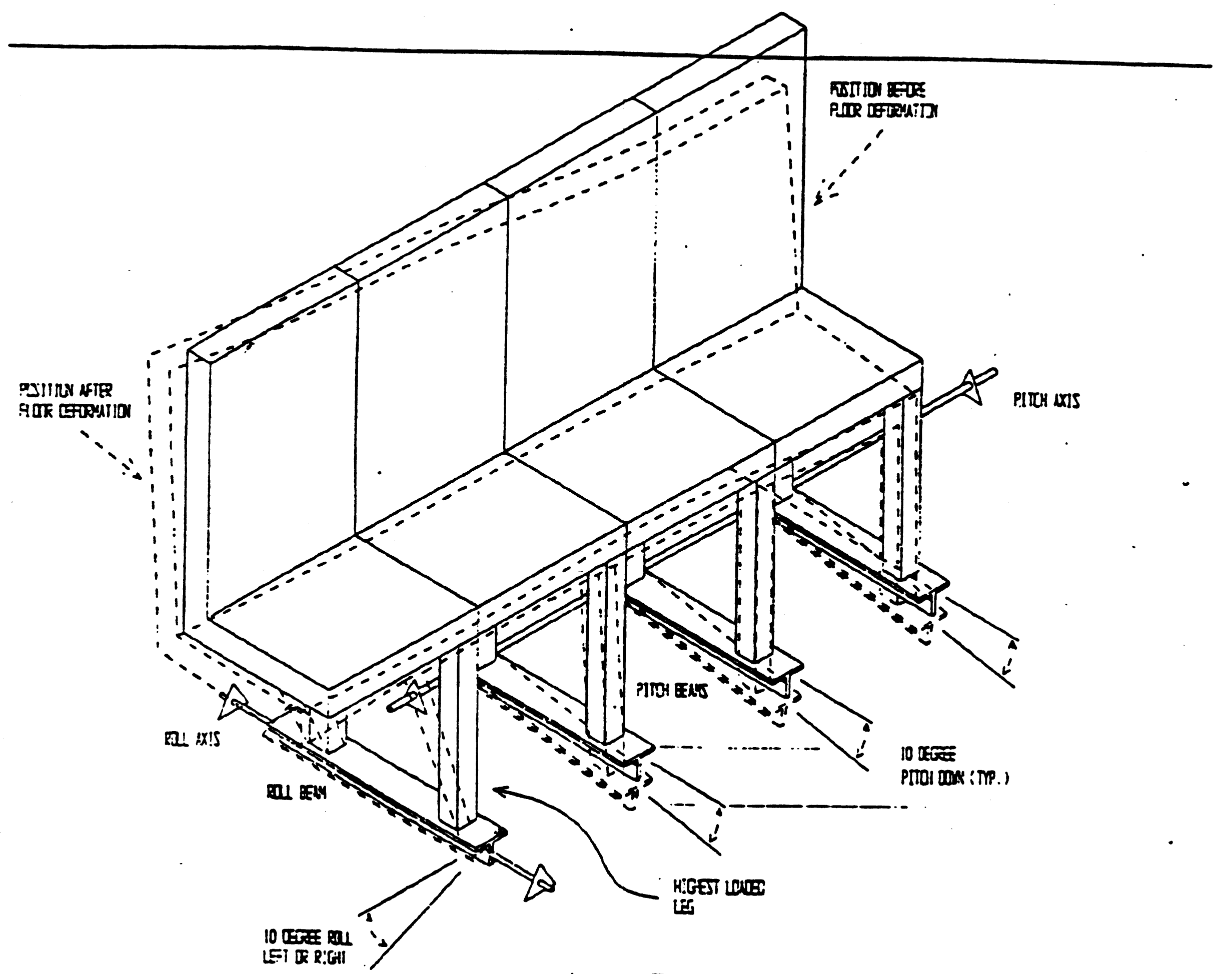

POSITION BEFORE
FLOOR DEFORMATION
POSITION AFTER
FLOOR DEFORMATION
PITCH AXIS
PITCH BEAMS
10 DEGREE
PITCH DOWN (TYP.)
ROLL AXIS
ROLL BEAM
HIGHEST LOADED
LEG
10 DEGREE ROLL
LEFT OR RIGHT

Figure 5.

(3) <u>Seats that are wall-mounted</u> must be evaluated individually. There are several types of mounting schemes, some of which are discussed below. As noted in the preamble to Amendment 25-64, the dynamic impact pulses defined in § 25.562 are considered compatible with existing airframe structure. The definition of the test fixture required for floor-mounted seats takes this into account, so that extensive floor structure is not necessary for test; that is, only the seat track above the floor is used. The important consideration is the retention of the seat under dynamic conditions, and the test setup should account for this in wall-mounted seats as well. The following guidance has been established with this objective in mind.

(i) <u>Seats that are mounted to primary airplane structure</u>, such as a pressure bulkhead, need only be tested with the attachment fitting mounted to rigid structure, in a manner equivalent to the production installation.

(ii) <u>Seats mounted to a structure, such as a structural bulkhead, galley or lavatory</u>, where no integral structural members are used for attachment, should be tested with the seat attached to segments of the mounting surface. These segments are typically eight inch by eight inch sections of the panel. These sections can, in turn, be mounted to a rigid structure.

(iii) <u>Seats that are mounted to single panel furnishings</u>, such as class dividers or windscreens, where the panel essentially fulfills the role of the legs, should be treated the same as floor mounted seats. For the purpose of conducting tests, the entire assembly, including the panel and its attachments, should be included in the test setup. In this case, floor warpage should be applied to track-mounted furnishings.

(4) <u>Seats that are attached to both the floor and a bulkhead</u> should be tested on a fixture that positions the bulkhead surface in a plane through the axis of rotation of the pitch beam. The bulkhead surface should be located perpendicular to the plane of the floor (the airplane floor surface, if one were present) in the undeformed condition, or in a manner appropriate to the intended installation. Either a rigid bulkhead simulation or an actual bulkhead panel can be used. If a test fixture with a rigid bulkhead simulation is used, the seat restraint system shall attach to fittings installed in a test panel equivalent to those used in the actual installation. The seat should be attached to the bulkhead and the floor in a manner representative of the airplane installation, and the floor shall then be deformed as described in paragraph 9b.

(5) <u>Seats that are mounted between sidewalls</u> or to the sidewall and floor of an aircraft shall be tested in a manner that simulates airplane fuselage cross-section deformation during a crash. Brackets shall be provided to attach the seat to the test fixture at the same level above the fixture floor representing the installation above the airplane floor where the inboard tracks or attachment is located. The roll axis should be approximately at the center of the outboard track.

A sidewall bracket shall be located on the roll beam. Then, as the beams are rotated to produce the most critical loading condition (sidewall rotates outward), the combined angular and transitional deformation will simulate the deformation that could take place in a crash (see Figure 6 for a schematic representation). The seat positioning pins or locks shall be fastened in the same manner as would be used in the airplane, including the adjustment of anti-rattle mechanisms, if provided.

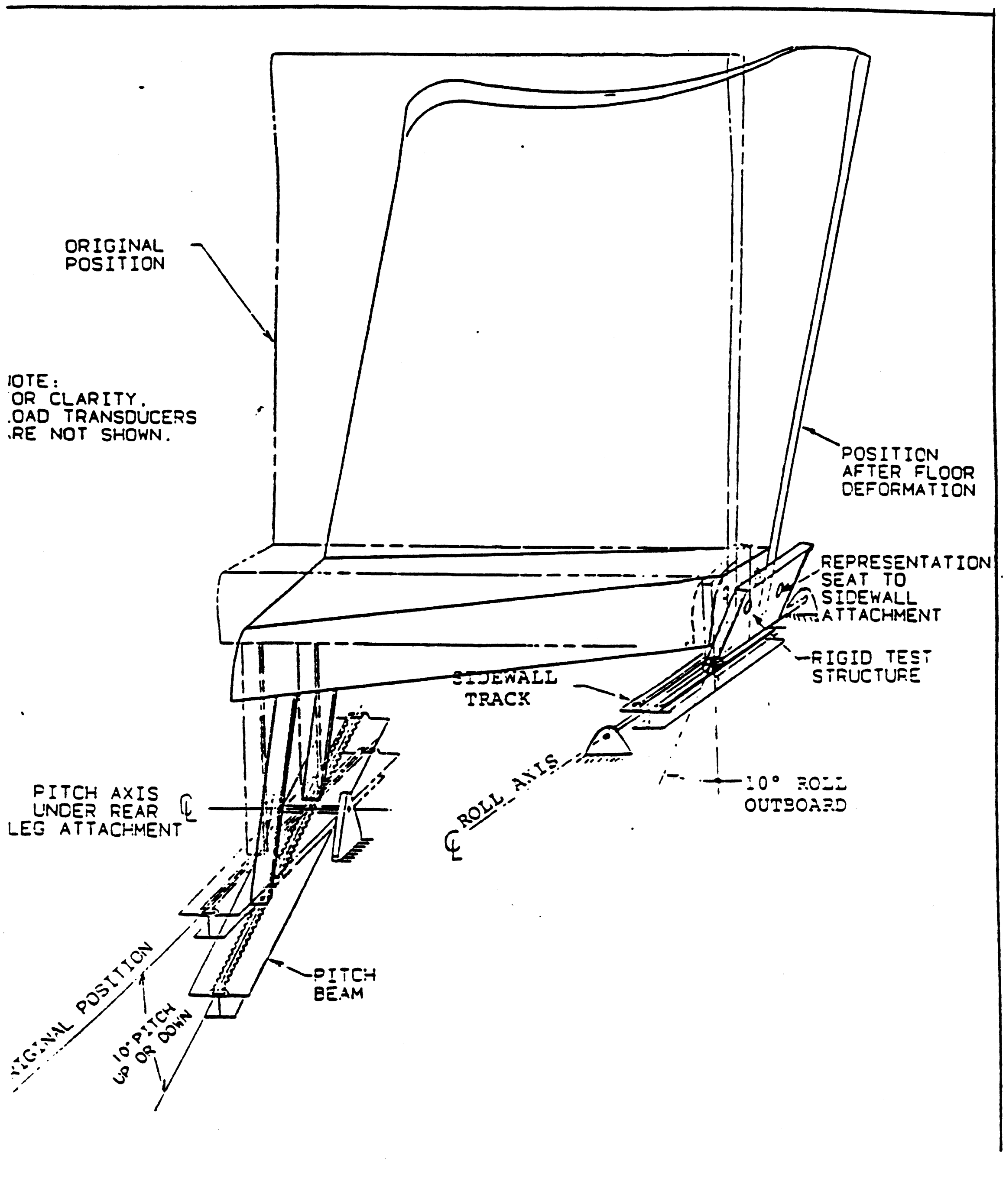


Figure 6. Schematic Test Fixture; Sidewall Mounted Seat

(6) <u>Seats that are cantilevered from one sidewall without connection to other structure</u> are not subject to floor deformation. A determination shall be made whether sidewall deformations could be expected that could generate a condition critical for seat performance in a crash. If sidewall deformation is likely, the entire sidewall attachment plane, or the attachment points, shall be deformed in a manner to represent the sidewall deformation. Either a rigid sidewall simulation or an actual sidewall panel may be used. If a test fixture with a rigid sidewall simulation is used, the seat/restraint system shall be attached to fittings installed in a test panel equivalent to those used in the actual installation.

(7) Seats that are mounted on a plinth. Where the plinth is used to mount a single seat, and the plinth is attached to the floor, the plinth should be considered as part of the seat assembly as an adaptor and should be deformed as described in paragraph 9b. Any items of mass attached to the plinth need to be represented and included in the dynamic testing.

(8) Seats that are mounted on a pallet (e.g., multiple seat rows). The pallet is considered part of the floor structure of the airplane. The seats should be attached to the pallet in a manner representative of the airplane installation. The seat legs should be deformed as described in paragraph 9b. Any items of mass attached to the pallet and not part of the seat structure do not need to be included in the dynamic testing.

d. <u>Side-Facing Seats</u>.

(1) <u>General</u>. All seats occupiable for takeoff and landing are subject to the specified dynamic test conditions, including side-facing seats, both single occupancy and multiple place (e.g. divans). Compliance with the structural requirements should be demonstrated for side-facing seats using the same conditions for the test and pass/fail criteria as for fore- and aft-facing seats. The seat should be loaded in the most critical case structurally. Means of restraining the ATDs may need to be adapted to ensure adequate retention during the test. The application of floor distortion will need to be assessed on an individual basis, depending on the design of the fixation of the seat. The injury criteria of § 25.562 are not adequate to demonstrate equivalent safety of side-facing seats when compared to fore- and aft-facing seats. To demonstrate equivalent safety fully in the absence of such specified criteria, the applicant must use other injury criteria which may be derived from the automotive industry, which uses side impact ATDs.

(2) Assessment Criteria. Research into side-facing seats is ongoing; therefore, in the absence of specific compliance guidance, the FAA is prepared to assess side-facing seats on the following basis:

(i) The seat must demonstrate compliance with the structural requirement.

(ii) If an acceptable side impact ATD has not been used with assessment of the corresponding injury criteria, it must be shown that the occupants are restrained in such a manner that prevents substantial energy absorption by body to body contact (on a multiple occupancy seat), and which, using the best available engineering judgment, minimizes injury to the occupant(s).

(iii) As research proceeds, the FAA will work toward establishing a more definitive policy with respect to the acceptance of side-facing seats.

e. Multiple Row Test Fixtures. In tests of passenger seats that are normally installed in repetitive rows in the airplane, head and knee impact conditions are best evaluated through tests that use at least two rows of seats. These conditions are usually critical only in Test 2. This test allows direct measurements of the head and femur injury data (see Figure 1).

(1) The fixture shall be capable of setting the airplane longitudinal axis at a yaw angle of -10 to +10 degrees. The fixture should also allow adjustment of the seat pitch and installation angle with respect to the airplane center line.

(2) To allow direct measurement of head acceleration for the head injury assessment of a seat installation where the head of the occupant is within striking distance of structure, a representative impact surface may be attached to the test fixture in front of the seat at the orientation and distance from the seat representing the airplane installation.

f. Other Fixture Applications. Test fixtures should provide a flat footrest for ATDs used in tests of passenger seats and crewmember seats that are not provided with special footrests or foot-operated airplane controls. The surface of the footrest shall be covered with carpet (or other appropriate material) and be at a position representative of the floor in the airplane installation. Test fixtures used for evaluating crew seats that are normally associated with special footrests or foot-operated controls shall simulate those components. Note: A footrest is optional for test 2 (see paragraph 10f). Test fixtures may also be required to provide guides or anchors for restraint systems or for holding instrument panels or bulkheads, if necessary, for the planned tests. If these provisions are required, the installation shall represent the configuration of the airplane installation and be of adequate structural strength.

10. Test Preparation.

a. Preparation for the tests will involve positioning and securing the ATD, the ATD restraint system, the seat, and the instrumentation. This will be done for the specific critical condition being tested. Preparations that pertain to the normal operation of the test facility, such as safety provisions and the actual procedures for accomplishment of the tests, are specific to the test facility and will not be addressed in this AC.

b. Use of anthropomorphic dummies. Anthropomorphic dummies used in the tests discussed in this AC should be maintained to perform in accordance with the requirements described in their specification. Periodic teardown and inspection of the ATD should be accomplished to identify and correct any worn or damaged components, and appropriate ATD calibration tests (as described in their specification) should be accomplished if major components are replaced. For the tests discussed in this AC, the following procedures have been found to be adequate:

(1) Since extremes of temperature and humidity can affect ATD performance, the ATDs should be maintained at a temperature range between 66 to 78 degrees F (19 to 26 degrees C) and at a relative humidity from 10 to 70 percent for a minimum of 4 hours prior to the test.

(2) Each ATD should be clothed in form-fitting cotton stretch garments with short sleeves, mid-calf length pants, and shoes (size 11E) weighing about 2.5 pounds. The color of the clothing should be in contrast to the color of the restraint system.

(3) For tests where the ATD's head is expected to impact a fixture or another seat back, the head and face of the ATD may be treated with a suitable material to mark head contact areas. The material used must not reduce the resulting HIC values.

(4) The friction in limb joints should be set so that they barely restrain the weight of the limb when extended horizontally.

(5) The ATD should be placed in the center of the seat, in as nearly a symmetrical position as possible. The ATD should be placed in the seat in a uniform manner so as to obtain reproducible test results.

(6) The ATD's back should be against the seat back without clearance. This condition can be achieved if the ATD's legs are lifted as it is lowered into the seat. Then, the ATD is pushed back into the seat back as it is lowered the last few inches into the seat pan. Once all lifting devices have been removed from the ATD, the ATD should be "rocked" slightly to settle it in the seat.

(7) The ATD's knees should be separated about four inches.

(8) The ATD's hands should be placed on the top of it's upper legs, just behind the knees. If tests on crew seats are conducted in a mockup that has airplane controls, the ATD's hands should be lightly tied to the controls.

(9) The feet should be in the appropriate position for the type of seat tested (flat on the floor for a passenger seat, on control pedals or on a 45 degree footrest for flightcrew systems). The feet should be placed so that the centerlines of

the lower legs are approximately parallel, unless the need for placing the feet on airplane controls dictates otherwise.

c. Seat adjustment. To the extent that they influence the injury criteria, all seat adjustments and controls should be in the design position intended for the 50th percentile male occupant. If seat restraint systems are being tested that are to be used in applications where special requirements dictate their position for landing or takeoff, those positions should be used in the tests.

d. Installation of instrumentation. Professional practice should be followed when installing instrumentation. Care should be taken when installing the transducers to prevent deformation of the transducer body that could cause errors in data. Lead-wires should be routed to avoid entanglement with the ATD or test article, and sufficient slack should be provided to allow motion of the ATD or test article without breaking the lead-wires or disconnecting the transducer. Calibration procedures should consider the effect of long transducer lead-wires. Head accelerometers and femur load cells should be installed in the ATD in accordance with the ATD specification and the instructions of the transducer manufacturer. The load cell between the pelvis and the lumbar column should be installed in accordance with the approach shown in Figure 2 of this AC, or in a manner that will provide equivalent data (see paragraph 7b).

(1) If an upper torso restraint is used, the tension load should be measured in a segment of webbing between the ATD's shoulders and the first contact of the webbing with hard structure (the anchor point or a webbing guide). Restraint webbing should not be cut to insert a load cell in series with the webbing, since that will change the characteristics of the restraint system. Load cells that can be placed over the webbing without cutting are commercially available. They should be placed on free webbing to minimize contact with hard structure, seat upholstery, or the ATD during the test. They should not be used on double-reeved webbing, multiple-layered webbing, locally stitched webbing, or folded webbing, unless it can be demonstrated that these conditions do not cause errors in the data. These load cells should be calibrated using a length of webbing of the type used in the restraint system. If the placement of the load cell on the webbing causes the restraint system to sag, the weight of the load cell can be supported by light string or tape that will break away during the test.

(2) Since load cells are sensitive to the inertial forces of their own internal mass and to the mass of fixtures located between them and the test article, as well as to forces applied by the test article, it may be necessary to compensate the test data for that inaccuracy if the error is significant. Data for such compensation will usually be obtained from an additional dynamic test that replicates the load cell installation, but does not include the test item.

e. Restraint system adjustment. The restraint system adjustment should be made as follows: The restraint system shall not be tightened beyond the level that could reasonably be expected in use, and the emergency locking device (inertia reel) shall not be locked prior to the impact. Automatic locking retractors shall be allowed to perform the webbing retraction and automatic locking function without assistance. Care shall be taken that emergency locking retractors that are sensitive to acceleration do not lock prior to the impact test because of preimpact acceleration applied by the test facility. If comfort zone retractors are used, they shall be adjusted in accordance with instructions given to the user of the restraint system.

(1) If manual adjustment of the restraint system is required, slack shall be removed, and the restraint system should be snug about the ATD. For test 2, this can normally be determined when two fingers will fit snugly between the belt and the pelvis of the ATD. The restraint system shall be checked and adjusted just prior to the floor deformation phase of the test.

(2) If the system is tested in other than a "horizontal floor" position, the restraint should be properly adjusted with the seat in the "horizontal floor" position and the webbing transducers installed (if required). After sufficient time has elapsed to allow the cushion to reach an equilibrium position, the webbing should be marked to indicate the correct adjustment point. The seat and ATD should then be installed on the fixture in the appropriate dynamic test orientation and the restraint system again adjusted to that same point.

(3) An alternate method to impose a 1-g preload is to measure the position of the ATD hip joints relative to the floor as shown in Figure 7 below. The ATD is then depressed into the cushion to reproduce this relative position after the ATD and seat have been installed on the fixture, as shown in Figure 8. The lap belt may be tightened to maintain this position. This load may make it impossible to insert two fingers between the lap belt and the pelvis of the ATD, but it should not produce a cushion displacement in excess of that measured by placing the ATD on the seat in a 1-g orientation.

f. A floor is not required for Test 2, STRUCTURAL TESTS, but if a floor is installed, it should not influence the behavior of the seat, or unduly restrict the movement of the ATD's feet. This is a concern especially when floor distortion is applied.

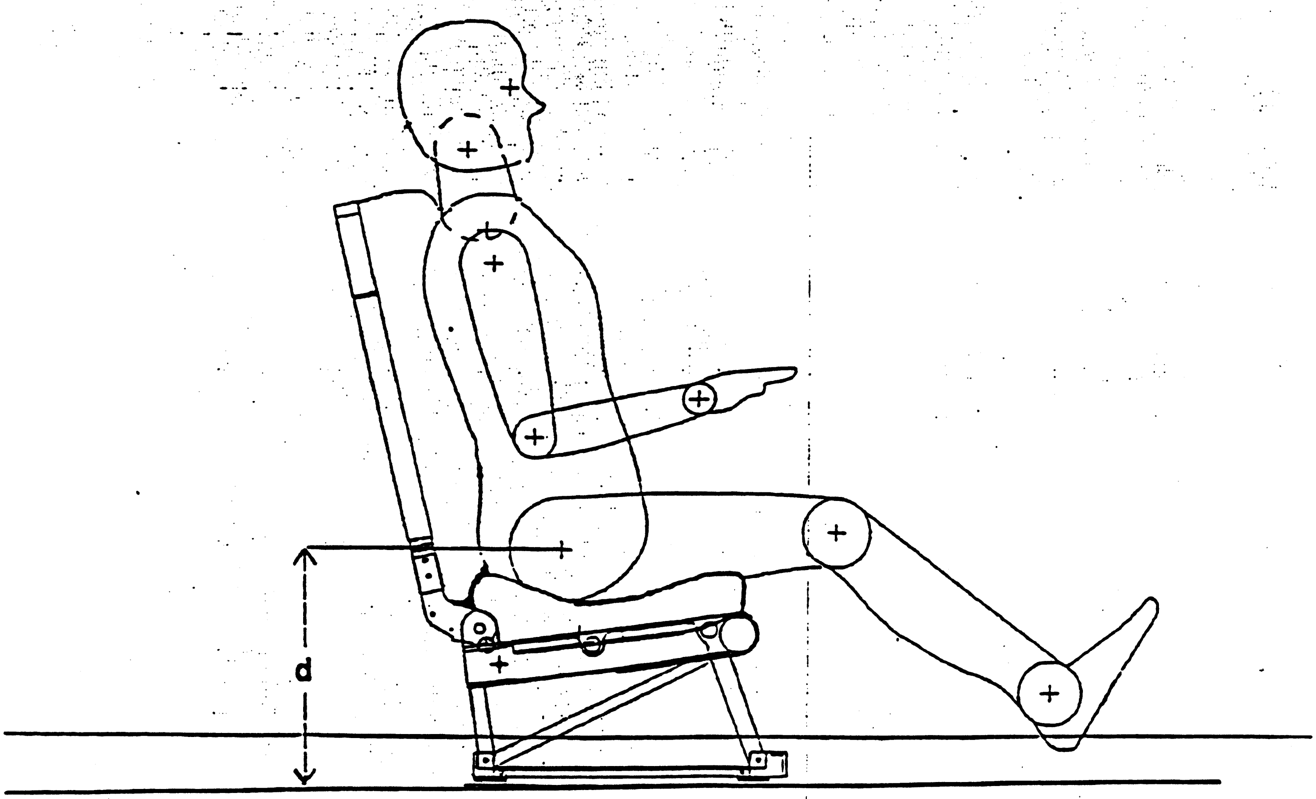


Figure 7.

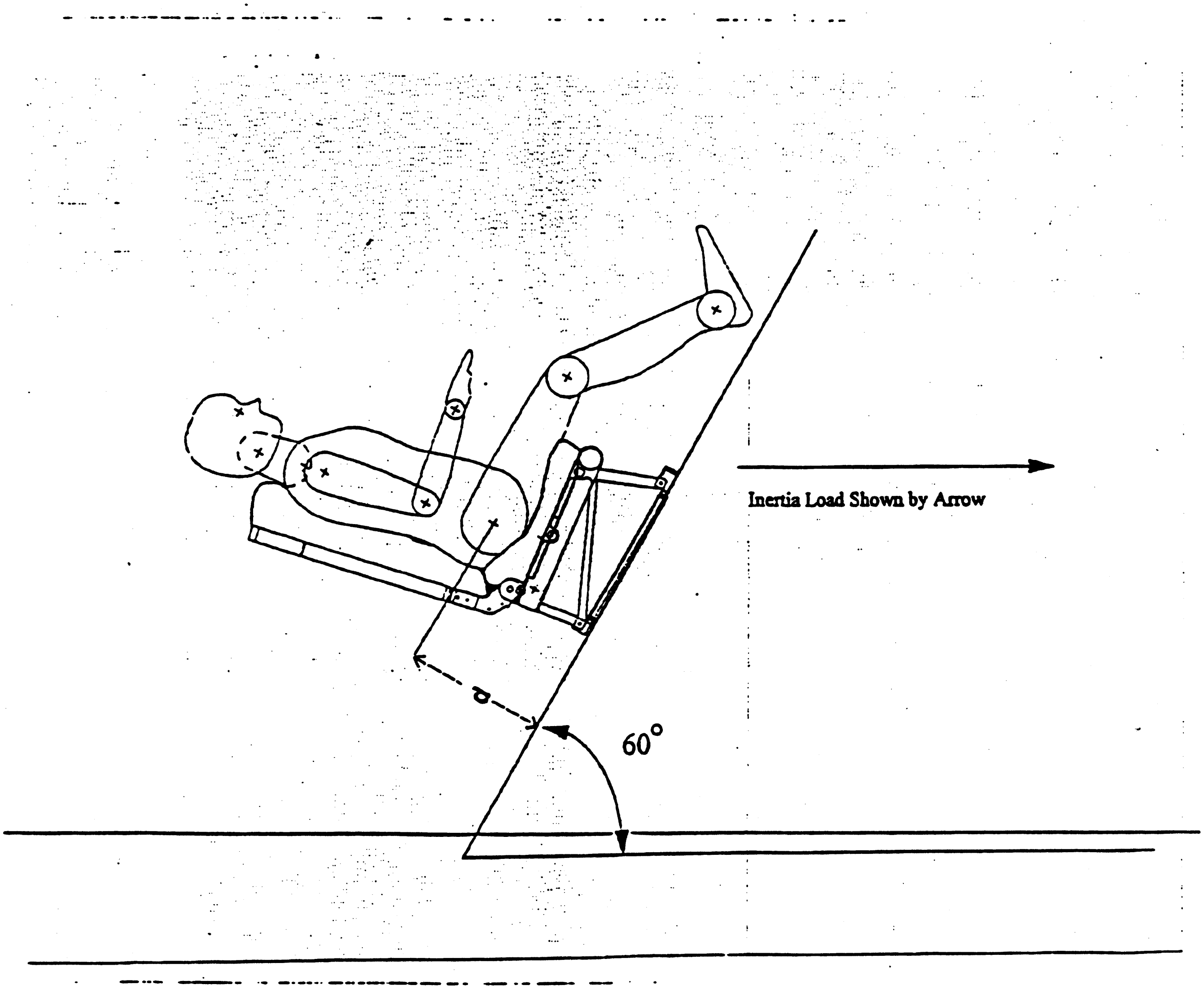


Figure 8.

11. DATA REQUIREMENTS. The data should include charts, listings, and/or tabulated results, and copies of any photo instrumentation used to support the results. The following should be recorded:

a. Impact pulse shape

b. Head Injury Criterion (HIC) results for all ATD's exposed to head impact with interior components of the airplane or head strike paths and velocities if head impact is likely but could not be evaluated by these tests

c. Total velocity change

d. Upper torso restraint system load, if applicable

e. Compressive load between the pelvis and the lumbar column

f. Retention of upper torso restraint straps, if applicable

g. Retention of pelvic restraint

h. Femur loads, if applicable

i. Seat attachment (including structural damage)

j. Seat deformation

k. Seat attachment reaction time histories

l. Retention of items of mass

m. Post test retrieval of life vest

n. Evaluation of seat egress

12. DATA ANALYSIS.

a. General. All data obtained in the dynamic tests should be reviewed for errors. Baseline drift, ringing, and other common electronic instrumentation problems should be detected and corrected before the tests. Loss of data during the test is readily observed in a plot of the data versus time and is typically indicated by sharp discontinuities in the data, often exceeding the amplitude limits of the data collection system. If these occur early in the test in essential data channels, the data should be rejected and the test repeated. If they occur late in the test after the maximum data in each channel has been recorded, the validity of the data should be carefully evaluated, and the maximum values of the data may still be acceptable for the tests described in this AC. The HIC does not represent simply a maximum data value, but an integration of data over a varying time base. The head acceleration measurements used for that computation are not acceptable if errors or loss of data are apparent in the data at any time, from the beginning of the test until the ATD and all test articles are at rest after the test.

b. Impact pulse shape. Data for evaluating the impact pulse shape is obtained from an accelerometer that measures the acceleration in the direction parallel to the inertial response shown in Figure 1 of this AC. The impact pulses intended for the tests discussed in this AC have an isosceles triangle shape. These ideal pulses are considered minimum test conditions. Since the actual acquired test pulses will differ from the ideal, it is necessary to evaluate the acquired test pulses to insure the minimum requirements are satisfied. The five properties of the ideal pulse that must be satisfied by the acquired test pulse are as follows (see Figure 1):

Pulse shape:	isosceles triangle
G_{req}:	peak deceleration required by test condition
T_{req}:	rise time required by test condition
V:	total velocity change required by test condition
V_{tr}:	velocity change required during T_{req} ($V_{tr} = V/2$)

A graphical technique can be used to evaluate pulse shapes that are not precise isosceles triangles. Appendix 1 of this AC presents the graphical method of evaluating the acquired pulse (the recorded test sled acceleration versus time). For the acquired pulse to be acceptable, the following five criteria must be met:

(1) The magnitude of the peak value for the acquired pulse, G_{pk}, must be greater than or equal to G_{req}.

(2) The actual rise time, $Tr = T_2 - T_1$, must be less than or equal to T_{req}.

(3) The result of integrating the acquired pulse during the interval from $t = T_1$ to $t = T_3$ must be equal to or greater than V_{tr}, one-half of the required velocity change for the specified test. If the magnitude of the acquired pulse is greater than the ideal pulse during the entire interval from T_1 to T_3, this requirement is automatically met.

(4) The result of integrating the acquired pulse during the interval from $t = T_1$ to $t = T_1 + 2.3\,(T_{req})$ must equal or exceed the required test velocity change, V, of the test condition. If the acquired pulse returns to zero g's at $t = T_4 < (T_1 + 2.3\,(T_{req}))$, the end of the interval of integration is reduced to $t = T_4$;

(5) If the magnitude of the acquired pulse is greater than the ideal pulse during the entire interval of $t = T_1$ to T_2, and the parameters of paragraphs (1) through (4) above are satisfied, then the acquired pulse is acceptable.

(6) If the magnitude of the acquired pulse is not greater than the ideal pulse during the entire interval $t = T_1$ to T_2, the difference between acquired pulse and the ideal must be no greater than 2.0 g's at those times when the acquired pulse is less than the ideal. The parameters of paragraphs (1), (2), and (3) above must also be satisfied for the acquired pulse to be acceptable.

c. Total Velocity Change. Impact velocity can be obtained by measurement of a time interval and a corresponding sled displacement that occurs just before or after (if appropriate) the test impact, and then dividing the displacement by the time interval. When making such a computation, the possible errors of the time and displacement measurements shall be used to calculate a possible velocity measurement error, and the test impact velocity should exceed the velocity shown in Figure 1 by at least the velocity measurement error. If the sled is not changing velocity during the immediate preimpact or postimpact interval, the impact velocity is the total velocity change. If the sled is changing velocity during the immediate pre-impact or post-impact interval, or if the facility produces significant rebound of the sled, the total velocity change can be determined by integrating the plot of sled acceleration versus time, as described in Appendix 1. If this method is used, the sled acceleration shall be measured in accordance with Channel Class 180 requirements.

d. Head Injury Criterion (HIC).

(1) Data for determining the Head Injury Criterion (HIC) need to be collected during the tests discussed in this AC only if the ATD's head is exposed to an impact on airplane interior features (not including the floor or the ATD's own leg) during the test. The HIC is calculated according to the following equation:

$$\mathrm{HIC} = \left[(t_2 - t_1)\left[\frac{1}{(t_2 - t_1)}\int_{t_1}^{t_2} a(t)\,dt\right]^{2.5}\right]_{max}$$

Where: t_1 and t_2 are any two points in time (in seconds) during the head impact, and a(t) is the resultant head acceleration (expressed in g's) during the head impact.

(2) The HIC is a method for defining an acceptable degree of occupant head injury. The HIC should not exceed 1000, for head impact against interior surfaces in a crash.

(3) The HIC is invariably calculated by computer based data analysis systems, and the discussion that follows outlines the basic method for computation . The HIC is based on data obtained from three mutually perpendicular accelerometers installed in the head of the ATD in accordance with the ATD specification. Data from these accelerometers are obtained using a data system conforming to Channel Class

1000, as described in SAE Recommended Practice J211. Only the data taken during head impact with the airplane interior need be considered; this is usually indicated in the data by a rapid change in the magnitude of the acceleration. Film of the test may show head impact that can be correlated with the acceleration data by using the time base common to both electronic and photographic instrumentation. Simple contact switches that do not significantly alter the surface profile could also be used to define the initial contact time.

(4) The magnitude of the resultant acceleration vector obtained from the three accelerometers is represented as a function of time. Then, beginning at the time of initial head contact (t_1), the average value of the resultant acceleration is found for each increasing increment of time (t_2-t_1), by integrating the curve between t_1 and t_2 and then dividing the integral value by the time (t_2-t_1). This calculation should use all data points provided by the minimum 8000 samples per second digital sampling rate for the integration. However, the maximizing time intervals need be no more precise than 0.001 seconds. The average values are then raised to the 2.5 power and multiplied by the corresponding increment of time (t_2-t_1).

(5) This procedure is then repeated, increasing t_1 by 0.001 seconds for each repetition. The maximum value of the set of computations obtained from this procedure is the HIC. The procedure may be simplified by noting that the maximum value will only occur in intervals where the resultant magnitude of acceleration at t_1 is equal to the resultant magnitude of acceleration at t_2, and when the average resultant acceleration in that interval is equal to 5/3 times the acceleration at t_1 or t_2. The HIC is usually reported as the maximum value, and the time interval during which the maximum value occurs is also given.

(6) In many cases, a full system sled test to evaluate specific occupant injury conditions may not be needed to evaluate a redesign of the seat system that affects only HIC. In such cases, the photometric head path data can be gathered and used to ensure no contact will occur, or to define the head angle and velocity at impact. These data can used in a component test of severity comparable to the whole system sled test. Other factors, such as the inertial response of the impact target, must be accounted for in the component test condition so that the impact condition is representative. Component testing methods must be demonstrably comparable to whole system sled tests as a HIC measure, and the specific methodology used will require approval by the FAA.

Additionally, a seat may be designed for use in multiple locations where head contact against a range on unknown bulkhead targets is anticipated (e.g., front row seats). For these seats, HIC may be measured using a representative impact target mounted in front of the seat at the installation setback, or range of setbacks. This target will represent typical fixtures such as galleys, partitions, lavatories, and closets, and its stiffness wil be representative for those monuments. If contact occurs, the HIC must be $\leq$ 1000.

e Upper torso restraint system load. The maximum load in the upper torso restraint system webbing can be obtained directly from a plot or listing of webbing load transducer output. If a three-axis load transducer, fixed to the test fixture, is used to obtain these data, the data from each axis shall be combined to provide the resultant vector magnitude. If necessary, corrections shall be made for the internal mass of the transducer and the fixture weight it supports. This correction will usually be necessary only when the inertial mass or fixture weight is high, or when the correction becomes critical to demonstrate that the measurements fall below the specified limits.

f. Compressive load between the pelvis and lumbar column. The maximum compressive load between the pelvis and the lumbar column of the ATD can be obtained directly from a plot or listing of the output of the load transducer at that location. Since most load cells will indicate tension as well as compression, care should be taken that the polarity of the data has been correctly identified.

g. Retention of upper torso restraint straps. Retention of the upper torso restraint straps on the ATD's shoulders can be verified by observation of photometric or documentary camera coverage. The straps must remain on the ATD's shoulder until the ATD rebounds after the test impact and the upper torso restraint straps are no longer carrying any load. The straps must not bear on the neck or side of the head and must not slip to the upper rounded portion of the upper arm during that time period.

h. Retention of pelvic restraint. Retention of the pelvic restraint on the ATD's pelvis can be verified by observation of photometric or documentary camera coverage. The pelvic restraint shall remain on the ATD's pelvis, bearing on or below each prominence representing the anterior superior iliac spine, until the ATD rebounds after the test impact and the pelvic restraint becomes slack. Provided that the pelvic restraint remains on the ATD's pelvis, traping of the belt between the leg and the pelvis is acceptable.

Movement of the pelvic restraint above the prominence is usually indicated by an abrupt displacement of the belt onto the ATD's soft abdominal insert which can be seen by careful observation of photo data from a camera located to provide a close view of the belt as it passes over the ATD's pelvis. This movement of the belt is sometimes indicated in measurements of pelvic restraint load (if such measurement are made) by a transient decrease or plateau in the belt force, as the belt slips over the prominence, followed by a gradual increase in belt force as the abdominal insert is loaded by the belt.

i. Femur load. Data for measuring femur loads can be collected in the tests discussed in this AC if the ATD's legs contact seats or other structure. Data need not be recorded in each individual test, if rational comparitive analysis is available for showing compliance.

13. PASS/FAIL CRITERIA. The dynamic impact tests shall demonstrate that:

a. Since the test methods described in this AC are ultimate load condtions, damage to the seat and restraint is expected. The regulation specifically accounts for yielding as an acceptable form of permanent damage. In addition, the following should be considered:

(1) The seat system remains attached to the test fixture at all points of attachment, the occupant restraint system remains attached at all points of attachment and the primary load path remains intact. For the purpose of showing compliance with the structural requirements of § 25.562, acceptable damage to the load-carrying structural elements include: bending deformation, tension deformation, compression crippling, and shear buckling. Cracking of structural elements and the shearing or separation of rivets and minor delamination of composite panels is allowed provided a continuous load path remains between the occupant and the seat attachments.

(2) Damage to seat belts, such as scuffing, fraying and breakage of fibers is considered acceptable. The seat belt should not be cut, or torn by features of the seat or the belt adjuster mechanism. Cuts or tears should be investigated as to their cause, and appropriate corrective action taken, although a retest may not be necessary.

b. If the ATD's head is exposed to impact with interior features during the test, a HIC of 1,000 is not exceeded.

c. Where upper torso restraint straps are used, tension loads in individual straps do not exceed 1,750 lbs.(7.78 kN). If dual straps are used for restraining the upper torso, the total strap tension load does not exceed 2,000 lbs.(8.90 kN).

d. The maximum compressive load measured between the pelvis and the lumbar column of the ATD does not exceed 1,500 lbs. (6.67 kN).

e. The upper torso restraint straps (where installed) remain on the ATD's shoulder during impact.

f. The pelvic restraint remains on the ATD's pelvis during impact.

g. Where leg contact with seats or other structure occurs, the axial compressive load in each femur does not exceed 2,250 lbs. (10.0 kN).

h. The seat permanent deformations are within the quantitative limits of Appendix 2 of this AC and will not significantly impede an occupant from releasing his restraints, standing, and exiting the seat. In no case should deformation of the seat cause entrapment of the occupant, whether or not the defined limits referenced in Appendix 2 are exceeded.

<u>NOTE</u>: It is assumed that the maximum seat deformation will result from the structural evaluation (i.e., single row Type 2 test). Once this is accomplished, it would not,

therefore, be considered necessary to repeat deformation measurements after the injury criteria (multiple row) tests, unless the structural and injury criteria tests were combined into one test.

i. All deployable items must remain stowed, unless it can be shown that they do not impede egress or cause serious injury (see appendix 2).

14. TEST DOCUMENTATION.

a. General. The tests should be documented in reports that describe the procedures, limitations, results, and deviations to the tests discussed in this AC. In addition to the specific data requirements specified in paragraph 11 of this AC, the documentation should include the following:

(1) Facility data.

(i) The name and address of the test facility performing the tests.

(ii) The name and telephone number of the individual at the test facility responsible for conducting the tests.

(iii) A brief description and/or photograph of each test fixture.

(iv) The date of the last instrumentation system calibration and the name and telephone number of the person responsible for instrumentation system calibration.

(v) A statement confirming that the data collection was done in accordance with the recommendations in this AC, or a detailed description of the actual calibration procedure used and technical analysis showing equivalence to the recommendations of this AC.

(vi) The manufacturer, governing specification, serial number, and test weight of the ATDs used in the tests, and a description of any modifications or repairs performed on the ATDs that could cause them to deviate from the specification.

(vii) A description of the photographic-instrumentation system used in the tests.

(2) Seat restraint system data.

(i) The manufacturer's name and identifying model numbers of the seat restraint system used in the tests, with a brief description of the system, including identification and a functional description of all major components and photographs or drawings, as applicable. Qualifying approvals, such as Technical Standard Order (TSO) authorizations, should be included.

(ii) For systems that are not symmetrical, an analysis supporting the selection of most critical conditions used in the tests.

b. Test Description. The description of the test should be documented in sufficient detail so that the tests could be reproduced simply by following the guidance given in the report. The procedures outlined in this AC can be referenced in the report, but should be supplemented by such details as are necessary to describe the unique conditions of the tests. For example:

(1) Pertinent dimensions and other details of the installation that are not included in the drawings of the test items should be provided. This can include footrests, restraint system webbing guides and restraint anchorages, "interior surface" simulations, bulkhead or sidewall attachments for seats or restraints, etc.

(2) The floor deformation procedure, guided by goals of most critical loading for the test articles, should be documented.

(3) The placement and characteristics of electronic and photographic instrumentation chosen for the test, beyond that information provided by the facility, should be documented. This can include special targets, grids, or marking used for interpretation of photo documentation, transducers, restraint system loads, floor reaction forces, or other measurements beyond those discussed in this AC.

(4) Any unusual or unique activity or event pertinent to conducting the test should be documented. This could include use of special "break away" restraints or support for the ATDs, test items or transducers, operational conditions or activities such as delayed or aborted test procedures, and failures of test fixtures, instrumentation system components, or ATDs.

(5) Any energy-absorbing features that are intended as part of the design, and the expected structural behavior that will result should be documented.

15. COMPUTER MODELS. Several computer models have been developed to represent the seat restraint/occupant system in a crash. Some of these models include representation of the vehicle interior as well. These models can vary in complexity from simple spring-mass dynamic models to exceedingly complex models, which can be of help in designing an entire work station. Validation of these models also varies, from no validation at all to complex validation efforts based on controlled testing and field experience. The use of these models during the design phase of seat restraint/interior systems for civil airplanes is encouraged. They can be of great assistance in predicting "most critical" conditions, in understanding the performance of systems when used by various sized occupants, in estimating head strike paths and velocities, and for many other uses of interest to the designer. The Federal Aviation

Administration will continue to assess the performance of dynamic computer models, and will issue appropriate advisory material should any of these techniques be found to be useful alternatives to the tests discussed in this AC.

APPENDIX 1
PROCEDURE FOR EVALUATING PULSE SHAPES

A.1

This graphical procedure may be used to evaluate the impact pulse shape acquired from a test. While this procedure is based on graphical concepts, an accurate evaluation of the pulse parameters should be obtained using the digitized data and computer algorithms that provide the analysis illustrated in the following steps:

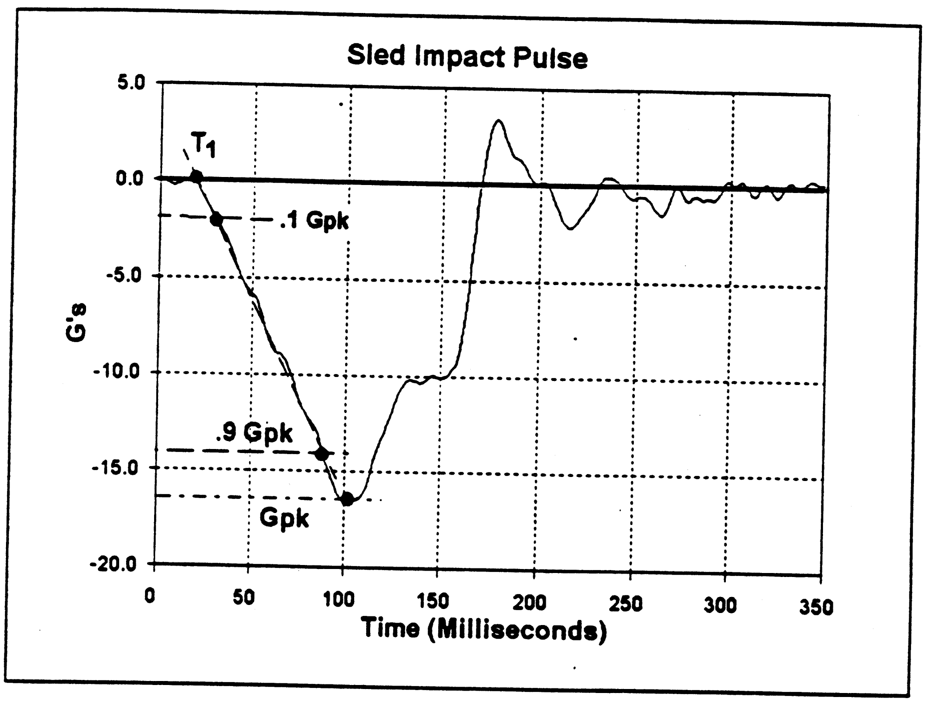


FIGURE A1

A.2 STEP 1:

On the plot of the acquire pulse, identify the peak deceleration point, Gpk, and points on the onset of the pulse equal to 0.1 Gpk and 0.9 Gpk. Construct an onset line through the points 0.1 Gpk and 0.9 Gpk. Extend the constructed onset line to the base line of the data plot, G=0. Identify the intersection of the constructed onset line and baseline as the start of the acquired pulse, T1. For the acquired pulse to be acceptable, the magnitude of Gpk must equal or exceed the minimum required pulse, Greq for the specified test condition.

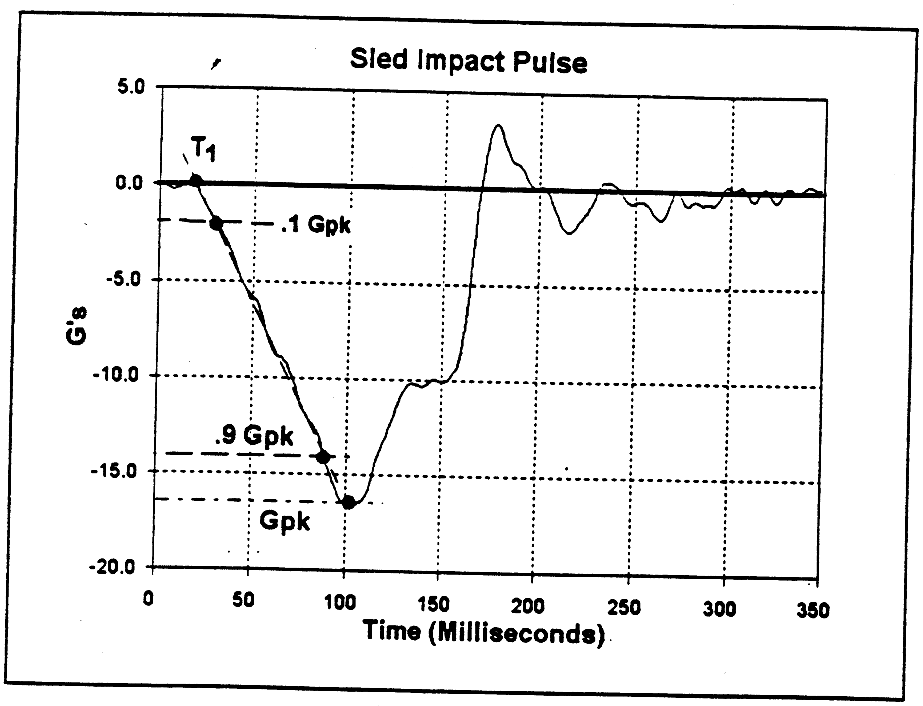


FIGURE A2

A.3 Step 2:

Using T_1 as the start time, construct the ideal pulse required for the test condition. Draw a vertical line and a horizontal line through the peak of the ideal pulse, Greq. The vertical line through Greq will intersect the time axis at the maximum allowed rise time, T_3. Draw another vertical line at the first intersection of the horizontal line through Greq and the acquired pulse after T_1. This vertical line will intersect the time axis at T_2. The actual rise time, $Tr = T_2 - T_1$, must be less than or equal to Treq for the acquired pulse to be acceptable.

A.4 Step 3:

Compute the velocity change, Vra, of the acquired pulse during the interval T_1 to T_3. Note that T_3 will usually occur after the peak, Gpk, of the acquired pulse. For the acquired pulse to be acceptable, Vra must be at least one-half the total velocity V, required for the specified test condition.

A.5 Step 4:

If the total velocity change for the test is calculated from the acquired pulse, use the interval starting at T_1 and ending:

a. at the point T4, where the acquired pulse first intersects the baseline, G = 0, after the time of Gpk or

b. at the time equal to: $T_1+2.3xTreq$ whichever occurs first.

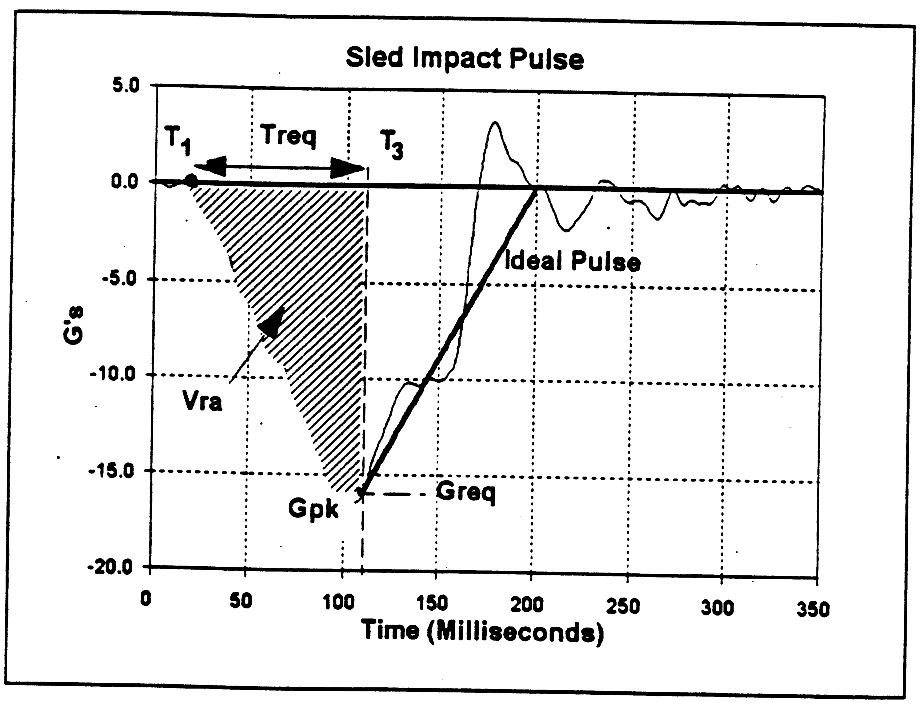


FIGURE A3

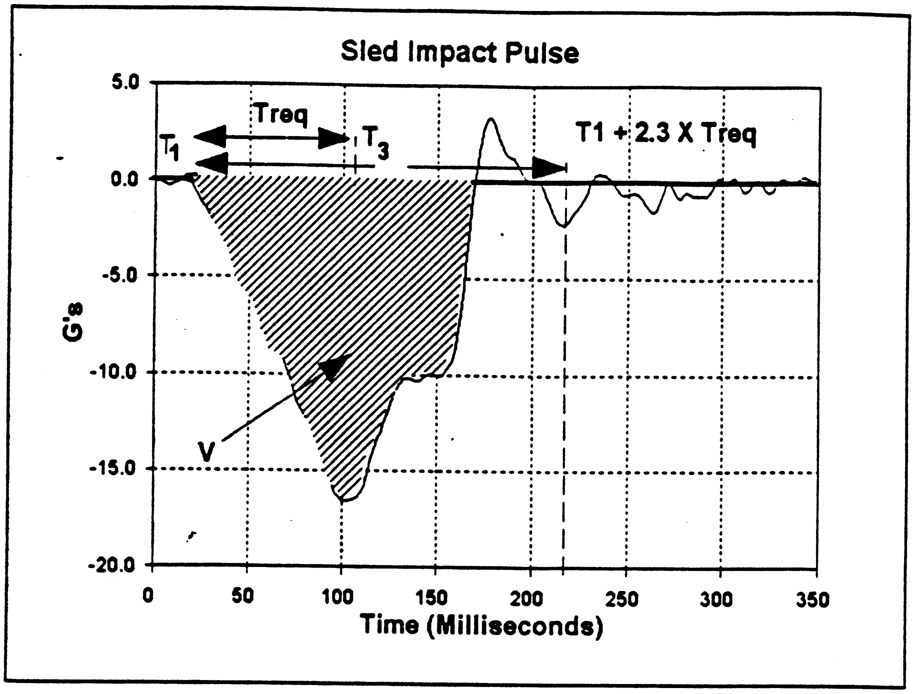

Sled Impact Pulse
5.0
0.0
-5.0
-10.0
-15.0
-20.0
G's
Treq
T1
T3
T1 + 2.3 X Treq
V
0
50
100
150
200
250
300
350
Time (Milliseconds)

FIGURE 4A4

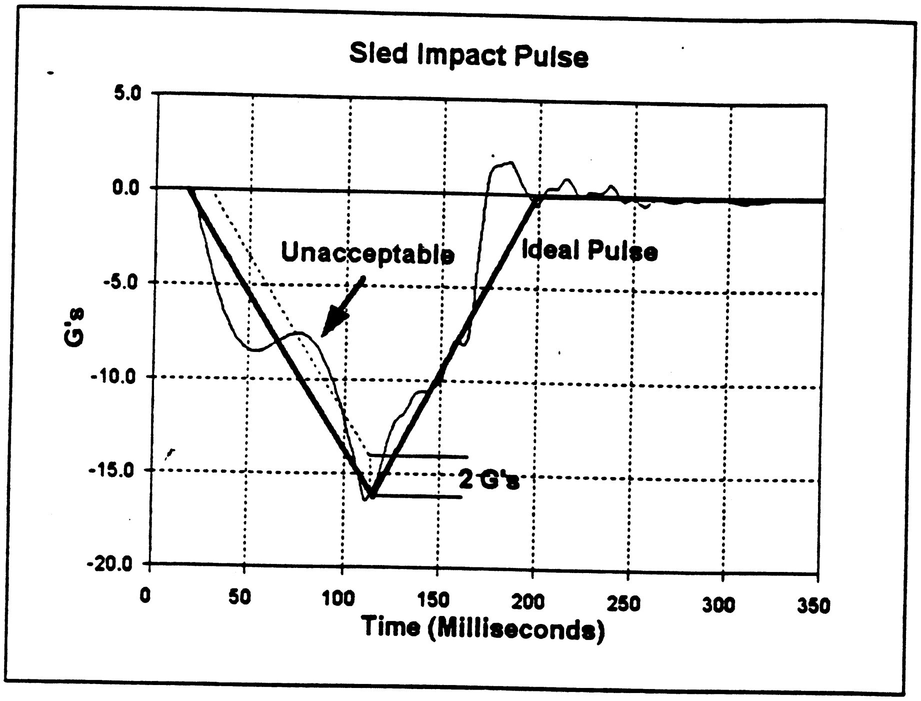


FIGURE A5

A.6 Step 5:

Construct a line parallel to the ideal pulse and offset by 2 G's in magnitude less than the ideal during the time interval between T1 and T2. If the magnitude of the acquired pulse is 2 G's less than the ideal at any point during the interval between T1 and T2, the pulse is not acceptable. Figure A2 is an example of an acceptable pulse shape. The acquired pulse shown in Figure A5 is unacceptable.

Appendix 2 - SEAT DEFORMATION

1. General. Seats that are evaluated in accordance with the tests discussed in this AC may deform either due to the action of discrete energy absorber systems included in the design or due to residual plastic deformation of their structural components. If this deformation is excessive, it could impede the airplane emergency evacuation process. Each seat design may differ in this regard and should be evaluated according to its unique deformation characteristics. If floor deformations are applicable, consistency in pre and post-test measurements shall be maintained. If the pretest measurements are made before floor deformations are applied, the post-test measurements shall be made after floor deformations have been removed. Conversely, if the pretest measurements are made after floor deformations are applied, the post-test measurements shall be made before removal of floor deformations.

2. Fixed Seats. The following post-test deformations and limitations regarding emergency exit egress may be used for showing compliance with §§ 25.561(d) and 25.562(c)(8). Dimensions specified for undeformed seat rows assume the maximum permanent deformation discussed below, and are given to enable evaluation of an installation without having to make reference to test reports. In those cases where the actual permanent deformations are less than maximum, the specified dimensions for undeformed seat rows could be correspondingly decreased.

a. Forward or Rearward Directions. Seats that exhibit forward or rearward deformations should not exceed a maximum of 3.0 inches (75 mm). In this case, the clearance between undeformed seat rows, measured as shown in Figure 1, Dimension A, of this appendix, should be 9.0 inches (228 mm) or, alternatively, 6.0 inches (150 mm), plus the actual fore/aft deformation. Seat rows that lead to Type III exits are subject to the specific access requirements for those exits. This will result in greater spacing at those seat rows in the undeformed case. For seats with deformations that exceed 3.0 inches, the undeformed clearances should be increased accordingly. In addition, at seat rows leading to Type III or IV exits, 20 inches (508 mm) minimum clearance, measured above the arm rests, shall be maintained between adjacent seat rows. This measurement may be made with the seat backs returned to their upright position, using no more than original seat back breakover forces, typically 25-35 pounds (111-155 N). At other seat rows, the most forward surface of the seat back shall not deform to a distance greater than one half the original distance to the forwardmost hard structure on the seat (see Figure 2 of this appendix).

b. Downward Direction. There is no limitation on downward permanent deformation, provided it can be demonstrated that the feet or legs of occupants will not be entrapped by the deformation.

c. Seat Rotation. The seat bottom rotational permanent deformation shall not result in an angle that exceeds 20 degrees pitch down or 35 degrees pitch up from the horizontal plane. This rotational deformation shall be measured between the fore and aft extremities of the seat pan at the centerline of each seat bottom (Figure 3 of this appendix). Rotation of the seat pan shall not cause entrapment of the occupant.

d. Sideward Direction.

(1) The deformed seat should not encroach more than 1.5 inches (38 mm) into the required longitudinal aisle space at heights up to 25 inches (635 mm)above the floor. The determination of which parts of the seat are at what heights is determined prior to testing.

(2) The deformed seat should not encroach more than 2.0 inches (50 mm)into the longitudinal aisle space at heights 25 inches (635 mm) or more above the floor.

e. Additional Considerations. In addition, none of the above deformations shall permit the seat to:

(1) Affect the operation of any emergency exit or encroach into an emergency exit opening for a distance from the exit not less than the width of the narrowest passenger seat installed in the airplane.

(2) Encroach into any required passageway.

(3) Encroach more than 1.5 inches (38 mm) into any cross-aisle or flight attendant assist space.

f. Deployable Items. Certain items on the seat, such as food trays, legrests, arm caps over in-arm tray tables, etc., are used by passengers in flight and are required to be stowed for taxi, takeoff and landing. Deployment of such items should be treated as "permanent deformation" if the item deploys into an area that must be used by multiple passengers (in addition to the occupant of the seat) for egress. Such deployments can be considered acceptable, even if they exceed the dimensions specified above, if they are readily pushed out of the way by normal passenger movement, and remain in a position that does not affect egress. [1]

3. Stowable Seats. Stowable seats, that may impede egress,must stow post-test and remain stowed to the extent necessary in order to satisfy the above criteria.

a. Seats that are Stowed Manually. A post-test stowage force no greater than 10 pounds (45 N) above the original stowage force may be used to stow the seat.

b. Seats that Stow Automatically. For a seat that may interfere with the opening of any exit, it must automatically retract to a position where it will not interfere with the exit. For determining encroachment into passageways, cross-aisles, andassist

[1] The underlined and bracketed section is my proposal. I think the wording "agreed" at the meeting is too loose. JG

spaces, a post-test stowage force no greater than 10 pounds (45 N), applied at a single point, may be used to assist automatic retraction.

Recommendation Letter

400 Main Street
East Hartford, Connecticut 06108

Pratt & Whitney
A United Technologies Company

April 18, 2000

Federal Aviation Administration
800 Independence Avenue, SW
Washington, DC 20591

Attention: Mr. Thomas McSweeny, Associate Administrator for Regulation and Certification

Subject: ARAC Recommendations

Reference: ARAC Tasking, Federal Register, November 19, 1999

Dear Tom,

The Transport Airplane and Engine Issues Group is pleased to submit the following "Fast Track" reports as recommendations to the FAA in accordance with the reference tasking. These reports have been prepared by the ~~Seat~~ Test Harmonization Working Group.

Task

1 • FAR 25.562 - 16G Seat Method of Compliance – ANM - 93 - 732 - ?

• FAR 25.785(c) - Seat Belts for Inflight Use Only

2 • FAR 25.785(e) + (b) - Occupant Protection – ANM - 98 - 439 - A

Please note that the Fast Track report for FAR 25.562 – 16G Seat Method of Compliance, has comments from the Association of Flight Attendants (AFA) attached. These comments were provided to the Working Group after the report had been accepted and unanimously agreed to by the Working Group membership. As such, the AFA comments have not been reviewed and discussed by the Working Group. At the request of AFA, TAEIG agreed to attach the comments to the report submittal and the Seat Test Working Group has agreed to review the comments when the package is returned to the Working Group for final review at Phase 4 of the Fast Track process.

Sincerely yours,

Craig R. Bolt

Craig R. Bolt
Assistant Chair, TAEIG

Attachments

Copy: Kris Carpenter, FAA-NWR
*Nick Calderone, Boeing
*Effie Upshaw, FAA Washington, DC

*letter only

crb02_040400

Acknowledgement Letter

U.S. Department
of Transportation

**Federal Aviation
Administration**

800 Independence Ave., S.W.
Washington, D.C. 20591

DEC 20 1995

Mr. Gerald R. Mack
Aviation Rulemaking Advisory Committee
Boeing Commercial Airplane Group
P.O. Box 3707, M/S 67-UM
Seattle, WA 98124-2207

Dear Mr. Mack:

Thank you for your October 27 letter forwarding the Aviation Rulemaking Advisory Committee's (ARAC) recommendation in the form of a draft Advisory Circular (AC) on Seat Dynamic Testing.

You stated that the recommendation reflects only the action that was chartered to ARAC; and that it does not signify industry's satisfaction with the rule. ARAC's position in this regard is noted. You also asked that any tasks involving a possible rule change or guidance on this issue, that evolve from the October 23 and 24 public meeting in Seattle, be given to ARAC, Transport Airplane and Engine issues. This request will be considered. With regard to the request not to identify ARAC products, that have been subsequently changed by the Federal Aviation Administration (FAA), as ARAC products, it is necessary that we accurately describe in our documents how we arrived at the proposed or final product; and this means citing the work done by ARAC. However, we understand your concern, and will be careful to show how the ARAC product was altered by the FAA.

I am aware that the ARAC vote on this recommendation included two dissenting votes. We have asked the organizations involved to provide us additional information so we can address their concerns in the public notice on this AC.

I would like to thank the aviation community, and particularly the Seat Testing Harmonization Working Group, for its commitment to ARAC and for its interest and effort on this project.

Sincerely,

Anthony J. Broderick
Associate Administrator for
Regulation and Certification

Recommendation

1 - What is underlying safety issue to be addressed by the FAR/JAR?

FAR 25.785(c) states that each seat and berth must be approved. The FAA requires all seats that are " in-flight only" to have a restraint system before they will be approved. The JAA does not require restraints for all seats that are not occupied for taxi, takeoff and landing. Harmonization on this issue is the goal.

2 - What are the current FAR and JAR standards relative to this subject?

The applicable regulations are:

Current FAR text: **Sec. 25.785 Seats, berths, safety belts, and harnesses.**

(c) Each seat or berth must be approved.

(f) Each seat or berth, and its supporting structure, and each safety belt or harness and its anchorage must be designed for an occupant weight of 170 pounds, considering the maximum load factors, inertia forces, and reactions among the occupant, seat, safety belt, and harness for each relevant flight and ground load condition (including the emergency landing conditions prescribed in Sec. 25.561). In addition--
(1) The structural analysis and testing of the seats, berths, and their supporting structures may be determined by assuming that the critical load in the forward, sideward, downward, upward, and rearward directions (as determined from the prescribed flight, ground, and emergency landing conditions) acts separately or using selected combinations of loads if the required strength in each specified direction is substantiated. The forward load factor need not be applied to safety belts for berths.
(2) Each pilot seat must be designed for the reactions resulting from the application of the pilot forces prescribed in Sec. 25.395.
(3) The inertia forces specified in Sec. 25.561 must be multiplied by a factor of 1.33 (instead of the fitting factor prescribed in Sec. 25.625) in determining the strength of the attachment of each seat to the structure and each belt or harness to the seat or structure.

[Doc. No. 24344, Amdt. 25-72, 55 FR 29780, July 20, 1990; as amended at Amdt. 25-88, 61 FR 57956, Nov. 8, 1996]

Current JAR text: **JAR 25.785 Seats, berths, safety belts and harnesses.**

Date: May 27, 1994

(c) Each seat or berth must be approved.

(f) Each seat or berth, and its supporting structure, and each safety belt or harness and its anchorage must be designed for an occupant weight of 170 pounds, considering the maximum load factors, inertia forces, and reactions among the occupant, seat, safety belt, and harness for each relevant flight and ground load condition (including the emergency landing conditions prescribed in JAR 25.561). In addition--
(1) The structural analysis and testing of the seats, berths, and their supporting structures may be determined by assuming that the critical load in the forward, sideward, downward, upward, and rearward directions (as determined from the prescribed flight, ground, and emergency landing conditions) acts separately or using

selected combinations of loads if the required strength in each specified direction is substantiated. The forward load factor need not be applied to safety belts for berths.
(2) Each pilot seat must be designed for the reactions resulting from the application of the pilot forces prescribed in JAR 25.395.
(3) For the determination of the strength of the local attachments (see ACJ 25.561(c)) of--
(i) Each seat to the structure; and
(ii) Each belt or harness to the seat or structure;
a multiplication factor of 1.33 instead of the fitting factor as defined in JAR 25.625 should be used for the inertia forces specified in JAR 25.561. (For the lateral forces according to JAR 25.561(b)(3) 1.33 times 3.0g should be used.)

2a – If no FAR or JAR standard exists, what means have been used to ensure this safety issue is addressed?

FAR and JAR Exist

3 - What are the differences in the FAA and JAA standards or policy and what do these differences result in?:

The difference in FAA and JAA standards resulted in certified seat installations that had seat belts in some cases, and did not have seat belts in other cases depending on the certifying regulatory agency.

4 - What, if any, are the differences in the current means of compliance?

See above.

5 – What is the proposed action?

No change to the regulation is required. JAA guidance material must be updated to reflect the FAA interpretation.

For each proposed change from the existing standard, answer the following questions:

6 - What should the harmonized standard be?

See ARAC-SHWG Task 2 Concept Paper (attached).

7 - How does this proposed standard address the underlying safety issue (identified under #1)?

This provides an improved level of safety for aircraft due to the addition of the restraint system on "in-flight only" seats.

8 - Relative to the current FAR, does the proposed standard increase, decrease, or maintain the same level of safety? Explain.

No change to the FAR.

9 - Relative to current industry practice, does the proposed standard increase, decrease, or maintain the same level of safety? Explain.

This provides an improved level of safety for aircraft due to the addition of the restraint system on "in-flight only" seats.

10 - What other options have been considered and why were they not selected?:

Both the FAA position, requiring seat belts on "in-flight only" and the JAA position not requiring restraints on these seats were considered.

11 - Who would be affected by the proposed change?

Seat suppliers and airframe manufacturers who traditionally certify through the JAA.

12 - To ensure harmonization, what current advisory material (e.g., ACJ, AMJ, AC, policy letters) needs to be included in the rule text or preamble?

No applicable guidance material exists.

13 - Is existing FAA advisory material adequate? If not, what advisory material should be adopted?

AC 25-17 should incorporate the contents of the concept paper.

14 - How does the proposed standard compare to the current ICAO standard?

Unknown

15 - Does the proposed standard affect other HWG's?

No impact

16 - What is the cost impact of complying with the proposed standard?

Cost of compliance, if any, would be small. Very few seat suppliers and airframe manufacturers have configurations that fall under this guidance. Since no retroactive application of this guidance has been considered, the existing airline fleet would not be impacted.

17. - If advisory or interpretive material is to be submitted, document the advisory or interpretive guidelines. If disagreement exists, document the disagreement.

All data for this task is contained in the attached concept paper.

18. - Does the HWG wish to answer any supplementary questions specific to this project?

No supplementary questions have been identified at this time.

19. – Does the HWG want to review the draft NPRM at "Phase 4" prior to publication in the Federal Register?

Yes. The ARAC-SHWG wishes to review the draft guidance material before it is adopted by the regulatory agencies.

SHWG Report for Task 2 - Seat Belts for In-Flight Only Seats - 25.785

20. – In light of the information provided in this report, does the HWG consider that the "Fast Track" process is appropriate for this rulemaking project, or is the project too complex or controversial for the Fast Track Process? Explain.

The Fast Track process is appropriate for this task.

ARAC Seat Harmonization Working Group

Concept Paper – Task 2 – Seat Belts for In-Flight Only Seats

Background

Recent cabin interior designs, especially for large transport aircraft, have introduced various types of seating for use by both passengers and crew during flight only as part of the aircraft type design. These are typically used occasionally during flight with the occupants returning to their designated seats for take-off and landing phase. The purpose of this advisory material is to clarify the need for restraints, in the form of seat belts, to be fitted to seats in this category.

However, it is recognized that unique features in cabin design present cabin items that could conceivably be used as 'occasional seats. Wherever practical, these items are to be placarded "No seat". Additionally, common sense must prevail and not require restraints to be fitted, For example, seat belts are not required for lavatory seats, escape slide bustles, floor mounted stowages, etc.

Issues relating to oxygen drops, lighted signs, etc. have been raised and are outside the scope of this working group. If these issues need to be addressed, a different team with the appropriate skills and knowledge should address them.

Seat Belts for In-Flight Only Seats

Restraints must be available for the seated occupant for in-flight only seats. For objects that are designed as seats, a lap restraint shall be provided. The seat and restraint system must be substantiated for in-flight loads and flammability requirements. The restraint installation shall be evaluated to ensure it does not pose a trip hazard during egress.

In order to be effective, it is understood that the seat (with restraint) must have back support.

Implementation of this guidance is intended for new certification programs. No retrofit of previously certified seat part numbers and installations is required.

Special seats designed for small airframe or corporate aircraft (under Part 25) may not practically accommodate seat belts. These designs should be reviewed on a case-by-case basis with the regulatory agency to understand if this criterion applies.

Quality and workmanship of the restraint system shall be consistent with TSO/JTSO C22 or TSO/JTSO C114 or equivalent.

1 - What is underlying safety issue to be addressed by the FAR/JAR?

The intent of this rule is to provide an appropriate means of occupant protection from corners and protrusions likely to cause injury during emergency conditions. The three specific areas of passenger seat certification issues to be harmonized:

a) Definition of design features considered sharp edges or inappropriate corners when exposed to seat occupants
b) In-Flight entertainment video arms
c) Seat back mounted accessories

2 - What are the current FAR and JAR standards relative to this subject?

The applicable regulations are:

Current FAR text: **Sec. 25.785 Seats, berths, safety belts, and harnesses.**

(b) Each seat, berth, safety belt, harness, and adjacent part of the airplane at each station designated as occupiable during takeoff and landing must be designed so that a person making proper use of these facilities will not suffer serious injury in an emergency landing as a result of the inertia forces specified in Secs. 25.561 and 25.562.

(e) Each berth must be designed so that the forward part has a padded end board, canvas diaphragm, or equivalent means, that can withstand the static load reaction of the occupant when subjected to the forward inertia force specified in Sec. 25.561. Berths must be free from corners and protuberances likely to cause injury to a person occupying the berth during emergency conditions.

[Doc. No. 24344, Amdt. 25-72, 55 FR 29780, July 20, 1990; as amended at Amdt. 25-88, 61 FR 57956, Nov. 8, 1996]

Current JAR text: **JAR 25.785 Seats, berths, safety belts and harnesses.**

Date: May 27, 1994

(b) Each seat, berth, safety belt, harness, and adjacent part of the aeroplane at each station designated as occupiable during take-off and landing must be designed so that a person making proper use of these facilities will not suffer serious injury in an emergency landing as a result of the inertia force specified in JAR 25.561 and JAR 25.562.

(e) Each berth must be designed so that the forward part has a padded end board, canvas diaphragm, or equivalent means, that can withstand the static load reaction of the occupant when subjected to the forward inertia force specified in JAR 25.561. Berths must be free from corners and protuberances likely to cause injury to a person occupying the berth during emergency conditions.

2a – If no FAR or JAR standard exists, what means have been used to ensure this safety issue is addressed?

FAR/JAR exist along with regulatory guidance material.

3 - What are the differences in the FAA and JAA standards or policy and what do these differences result in?:

The FAR and JAR regulations are the same. Differences exist in the means of compliance to the regulations.

4 - What, if any, are the differences in the current means of compliance?

Differences in the current method(s) of compliance are generally:

a) *No industry standards exist for determination of injurious edges, corners and protrusions. Different judgement was applied with different regulatory agencies.*

b) *No standard method of certifying in-arm video monitors existed. The FAA applied one standard of test/analysis and the JAA applied a different standard for test/analysis.*

c) *No standard method of certifying seat back mounted accessories existed. The FAA applied one standard of test/analysis and the JAA applied a different standard for test/analysis.*

5 – What is the proposed action?

Develop harmonized means of compliance based on accepted industry design data and certification practices. All industry and regulatory agencies agree to implement the new methods of compliance.

For each proposed change from the existing standard, answer the following questions:

6 - What should the harmonized standard be?

See attached concept paper for Task 3.

7 - How does this proposed standard address the underlying safety issue (identified under #1)?

Use of the principles in the concept paper result in an equivalent level of safety that is mutually acceptable by the FAA and JAA.

8 - Relative to the current FAR, does the proposed standard increase, decrease, or maintain the same level of safety? Explain

The concept paper maintains the current level of safety. The regulation remains the same. The means of showing compliance has been standardized and clarified for all industry participants.

9 - Relative to current industry practice, does the proposed standard increase, decrease, or maintain the same level of safety? Explain.

The concept paper maintains the current level of safety. The means of showing compliance has been standardized and clarified for all industry participants.

10 - What other options have been considered and why were they not selected?:

Standards from other industries (automobiles, child play equipment, SAE design standards, etc.) were surveyed. Current company-proprietary methods of *compliance were researched. Elements of these standards have been incorporated into the ARAC-SHWG concept paper as they applied to aircraft seating.*

11 - Who would be affected by the proposed change?

The seat suppliers, airframe manufacturers, regulatory authorities and airlines would have the choice of using the new ARAC-SHWG Task 3 concept paper approach or using previously agreed upon practices with the applicable regulatory agency.

12 - To ensure harmonization, what current advisory material (e.g., ACJ, AMJ, AC, policy letters) needs to be included in the rule text or preamble?

AC 25-17 – Crashworthiness Handbook

13 - Is existing FAA advisory material adequate? If not, what advisory material should be adopted?

The content of ARAC-SHWG Task 3 Concept Paper should be adopted as FAA guidance material.

14 - How does the proposed standard compare to the current ICAO standard?

Unknown at this time

15 - Does the proposed standard affect other HWG's?

No

16 - What is the cost impact of complying with the proposed standard?

The cost impact expectations are as follows:

a) *There is no anticipated cost impact for the sharp edges/corners/protrusions standards.*

b) *There is a nominal cost impact for implementing standardized in-arm video testing/analysis. The reduced cost of testing for current FAA certification programs is expected to be offset by the increased testing for JAA programs. Testing costs should decline as in-arm video system design matures.*

c) *Same as (b) above for seat back mounted accessories.*

17. - If advisory or interpretive material is to be submitted, document the advisory or interpretive guidelines. If disagreement exists, document the disagreement.

All data for this task is contained in the attached concept paper.

18. - Does the HWG wish to answer any supplementary questions specific to this project?

No supplementary questions have been identified at this time.

19. – Does the HWG want to review the draft NPRM at "Phase 4" prior to publication in the Federal Register?

Yes. The ARAC-SHWG wishes to review the draft guidance material before it is adopted by the regulatory agencies.

20. – In light of the information provided in this report, does the HWG consider that the "Fast Track" process is appropriate for this rulemaking project, or is the project too complex or controversial for the Fast Track Process? Explain.

The Fast Track process is appropriate for this task.

1.0 Introduction

This concept paper outlines the harmonized guidance on occupant protection for FAR/JAR 25.785 for passenger seats. This guidance is divided in three sections; general design practices, in-arm video certification and seat back mounted accessory certification. This concept paper separately considers aircraft that have Amendment 25-64 as part of the certification basis as well as Pre-amendment 25-64 aircraft.

For these sections, two types of injury mechanisms are considered in the compliance criteria. The first is blunt trauma injury. This is a deceleration injury based on head impact. Typical criteria used in assessing this type of injury are Head Injury Criteria (HIC), average G and kinetic energy. For aircraft with 25.562(c)(5) as part of the certification basis, HIC must be used. For other aircraft, several methods of assessing blunt impact trauma are acceptable.

The other injury mechanism is due to impact with sharp edges. This is further divided into general design criteria for parts of the seat that are exposed to the passengers under normal use, and the assessment of potential sharp edges after an impact or abuse load scenario on the seat.

2.0 Related Regulations (14 CFR & JAR 25 Change 14)

25.562 – This requires that the seat and restraint system be designed such that each occupant is protected during emergency landing conditions. Specific criteria are included to facilitate finding compliance with this regulation.

25.601 – The airplane shall not have design features or details that experience has shown to be hazardous or unreliable. The suitability of each questionable design detail and part must be established by tests.

25.785 (b) – This requires each seat, berth, safety belt, harness and adjacent part of the airplane at each station designated as occupiable during take-off and landing must be designed so a person making proper use of these facilities will not suffer serious injury in an emergency landing as a result of the inertial forces specified in 25.561 and 25.562.

25.785(k) – This requires each projecting object that would injure persons seated or moving about the airplane in normal flight must be padded.

Although 25.785(b) and (k) require consideration of more than seats and berths when establishing compliance, the guidance in this concept paper has been specifically developed for seating systems. Furthermore, these requirements address two scenarios, those associated with an emergency landing and those associated with normal flight. From the regulation wording, it is evident that the extent of the acceptable injuries differs between the two scenarios. For emergency landing, serious injuries must be prevented, whereas in normal flight, any projecting object that could cause injuries must be padded. For example, minor cuts and abrasions could be accepted as not causing serious injury in the case of emergency landing condition, but would not be acceptable in the normal flight condition scenario.

3.0 Definitions

Exposed: An exposed component of a seating system is a component that a person may contact under normal function/operation of the seating system as installed in the aircraft. This would exclude components that are discretely located (not normally contacted) or only accessed during maintenance, repair or assembly of the seating system.

Head Contactable surface: Any surface within the specified zone (head strike zone) that can be contacted by 165-mm diameter head form. The head size is taken from the ATD specified in FAR/JAR 25.562

Head Strike Zone:

a) Aircraft without 25.562(c)(5) in the certification basis – The area defined as a 35 inch arc from the seat CRP bounded by the inside of the arm rests. The seat pitch is representative of the aircraft installation. This is established independent of seat orientation or installation angle (up to 18 degrees). Seats at angles 18 degrees and greater are considered side facing seats and beyond the scope of this document.

   When determining the head strike zone on the seat back ahead of the occupant, some nominal forward rotation of the seat back can be considered. The amount of seat back rotation is dependent upon the particular seat design and should be proposed as part of the head strike analysis. The forward rotation allowed in the analysis is to account for the "free play" or break-over provisions in the seat back. It is not intended to account for forward deformation of the seat back during a crash event.

b) Aircraft with 25.562(c)(5) in the certification basis – The head path collected by 16g forward tests for 25.562.

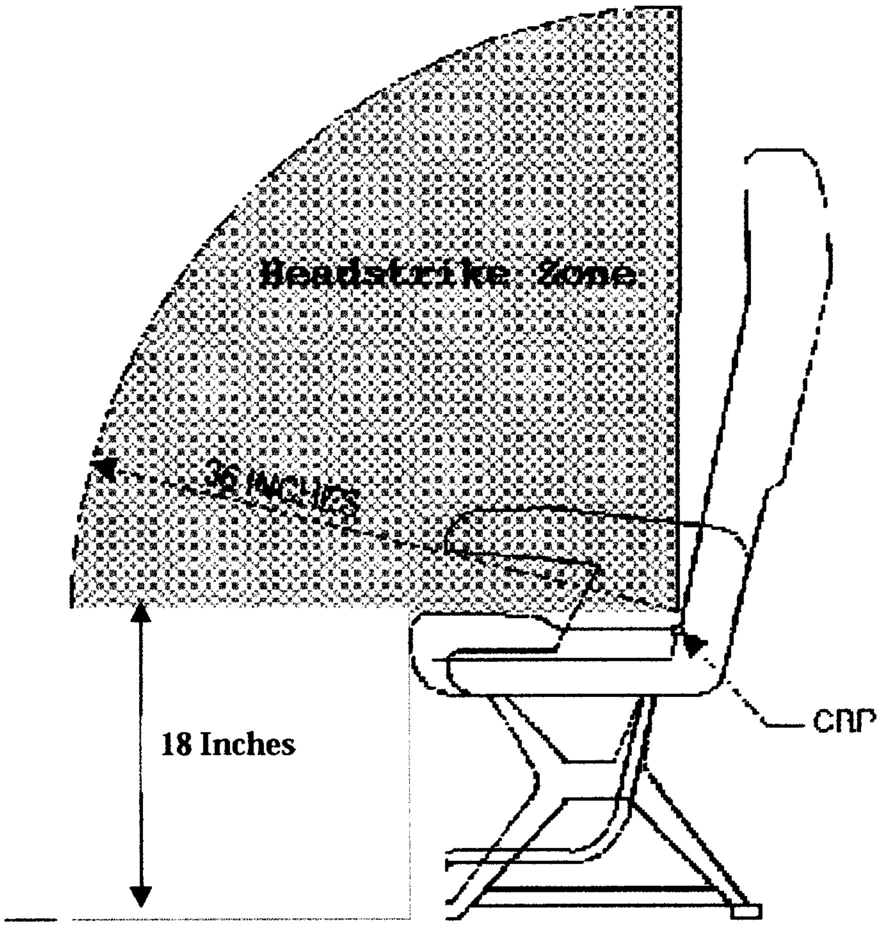


Figure 1a – Pre-amendment 25-64 Head Strike Zone

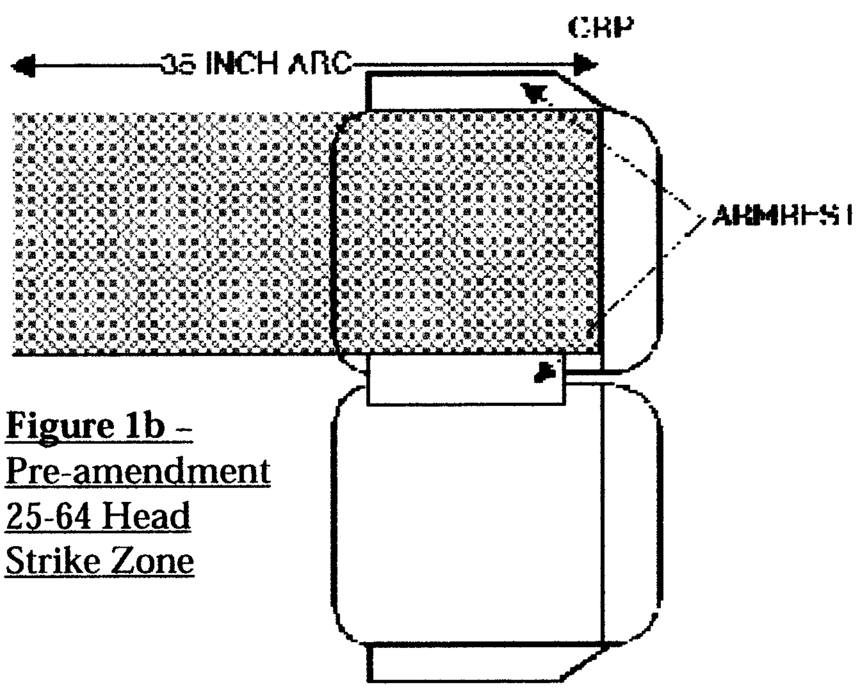
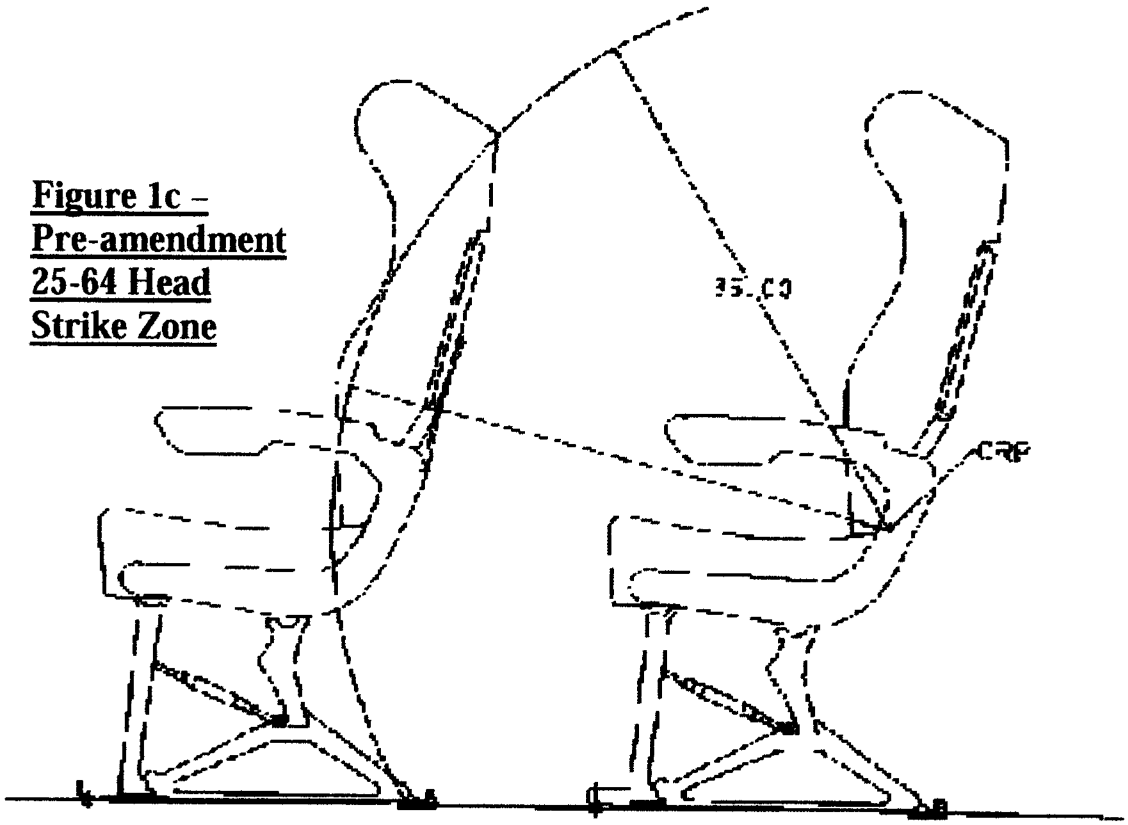


Figure 1b – Pre-amendment 25-64 Head Strike Zone

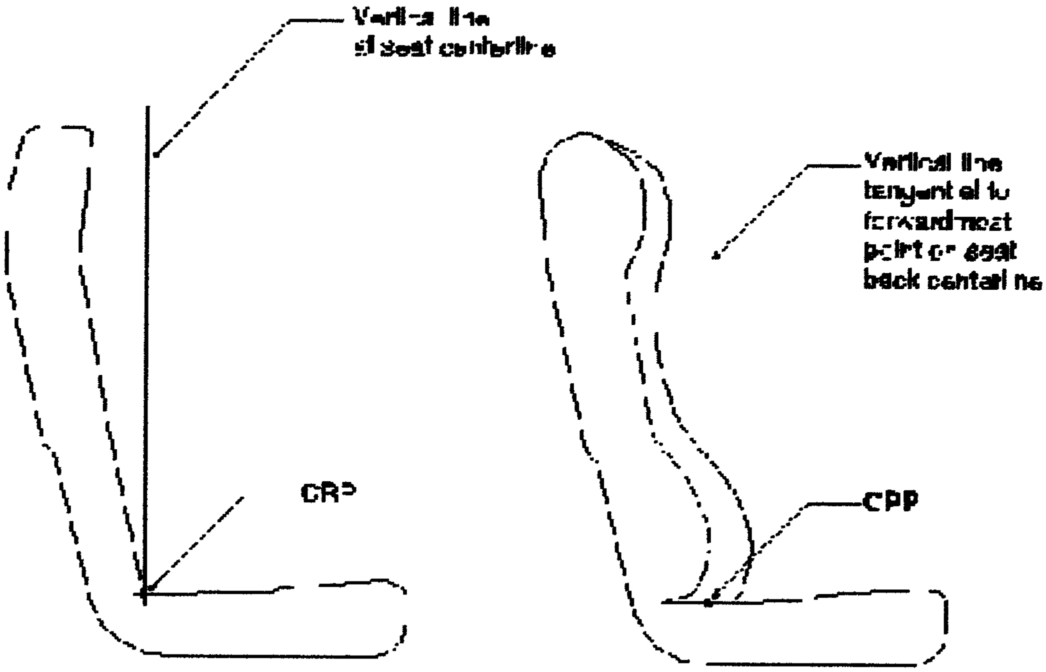
Figure 1c – Pre-amendment 25-64 Head Strike Zone



CRP: Cushion Reference Point. The cushion reference point is defined as the intersection of the top surface of bottom cushion and a vertical line tangential to the forward most point of the seatback, measured at the center of the seat back with the seat back in the full upright position. If the seat has adjustable lumbar support, this support should be deployed in its most "forward" setting to determine CRP.

This procedure for locating CRP is applicable only for aircraft without 25.562(c)(5) as part of the certification basis. It is used to determine the 35-inch

head strike zone..



Definition of CRP for conventional seat

Definition of CRP for seat with lumbar support

4.0 General Seat Design for Edges and Corners and Projections

4.1 Design Criteria for the Head Strike Zone

FAR 25.785 requires passengers be protected from serious head injury by use of a safety belt plus the elimination of any injurious object within striking radius of the head. This applies to use of the seat in in-flight situations and emergency landing scenarios.

For aircraft that are not required to comply with 25.562(c)(5), the head path is 35 inches from the cushion reference point (CRP). The width of the head strike zone extends to the inner surfaces of the armrests (or in the absence of an armrest, the restraint anchor points) (see Figure 1).
Any object which can be contacted which is 18 inches or greater above the floor should be considered in the head strike zone and assessed for sharp edges and projections using the Table A below.

For aircraft that must comply with FAR/JAR 25.562(c)(5), the head path is determined by dynamic tests/analysis conducted for 25.562 compliance.

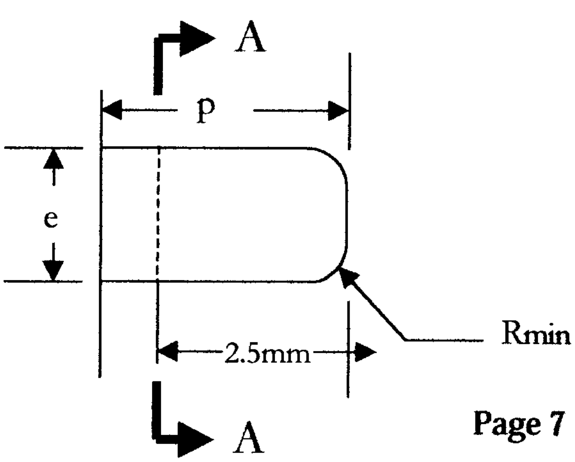
The design criteria outlined in the table below are used to determine if a seat feature is considered a hazardous object/projection. If it is not considered a hazardous object/projection, no further action is required (e.g. no padding is required). If it is considered a hazardous object/projection and it is in the head path, the object must be padded per 25.785(k).

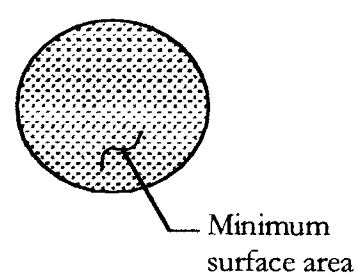
Table A - Design Criteria for Interior Compliance Inspection

Projection in the Contact Region (See figure below)	Minimum radius	Minimum Cross Sectional Area (measured @ 2.5 mm from contact surface perpendicular to the surface)
0 – 3.2 mm	2.5 mm*	N/A
3.2 mm – 9.5 mm	2.5 mm	2.0 cm^2
9.5 mm – 25.0 mm **	3.2 mm	6.5 cm^2
Exposed Edges in the Contact Region (See Figure 2 below)	3.2mm	6.5 cm^2 or greater
Corners	3.2mm	

* If the width is less than 2 times the projection ($e < 2p$), the minimum radius is 0.5 mm (blunt edges). [Width = e; Length of Projection = p]

** **Larger projections within this range should be oriented such that they are not in line with the head strike path. Designs should "shelter" these types of projections from direct head strike. Projections longer than 25.0 mm should be considered on a case-by-case basis with the appropriate regulatory agency.**





View A-A

Figure 1

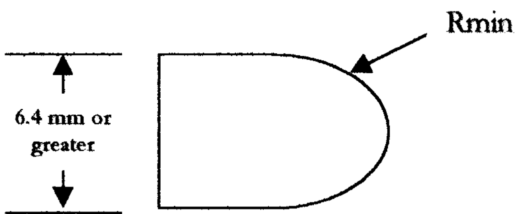


Figure 2

Reference:

1. NASA-STD-3000, volume 1, Rev B July 1995
2. 16 CFR 1500.48, Technical requirements for determining a sharp point in toys and other articles intended for use by children under 8 years of age.
3. 16 CFR 1500.49, Technical requirements for determining a sharp metal or glass edge in toys and other articles intended for use by children under 8 years of age.
4. 49 CFR 571.201 S3.4 Sun Visors
5. Economic Commission Europe, Regulation 21.01 Supplement 2, Interior Fittings.
6. 74/60/EEC & 78/632/EEC, Interior Fittings.
7. U.S. Consumer Product Safety Commission Publication 325, Handbook for Playground Safety, sections 9.1-9.5.

When assessing protrusions that may be contacted by the head, the potential orientation of the contact, by the head should be considered. For example, an object mounted on a seatback may be contacted by a person, during turbulence or emergency landing conditions, in a downward motion or a direct horizontal impact but would not be impacted in an upward motion.

Soft materials (for example, fabric, thin thermoformed plastics, foam or rubber) do not have minimum radius criteria since they do not pose an occupant injury hazard.

4.2 Consideration of Provisions for Seat Back Accessories

A seating system may be designed so that optional equipment, in the head strike zone, may be installed at some future time (e.g. a cutout in the seatback structure for a telephone or video monitor). The provisions should be assessed as detailed in the table above. If the provision results in a bare metal edge, it is not sufficient to simply hide the metal edge with a dress cover. It should be designed to either present a radius as shown in the table above or there should be a shield to deflect a head from directly contacting the edge (e.g. cover the area with a protective thermoplastic shroud etc.). The provision covering may require data/analysis demonstrating that it will not, in itself, produce sharp edges upon impact in an emergency-landing situation (for example, the cover for accessory provisions may be supported by 16g HIC test data, component test data, design experience, etc. to substantiate that it will not fracture with injurious fragments).

A separate assessment of the accessory should be conducted when it is installed into the seat back. This assessment should be conducted as part of the compliance finding for installing this equipment (for example, an injury assessment should be conducted when installing a seat back telephone into previously designed provisions during an STC certification).

5.0 Certification of In-Arm Monitors

5.1 General

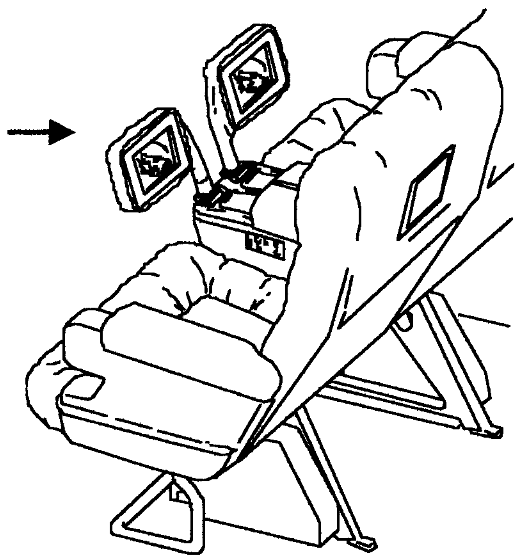
Design of in-arm video monitors should consider three scenarios:

- Contact with arm and monitor during normal use by the passenger/cabin crew member
- Performance of the arm and monitor in an abuse loading scenario
- Performance of the arm and monitor in an emergency landing scenario

These three scenarios can be evaluated independently of each other. For the second scenario, post abuse-load sharp edges must be evaluated. For the third scenario, blunt trauma from an emergency landing head strike should be evaluated if applicable.

	Blunt Trauma	Post-Impact Sharp Edges	Design Standards
9g	No Test*	SAE ARP	Industry Standards
16g	No Test*	SAE ARP	Industry Standards

* For systems stowed for taxi, takeoff and landing



5.2 Normal Use

In-arm video units, just as all seat components, must be designed such that they do not present an injury hazard to the occupant (either seated or moving about the cabin during flight). The edge/corner design criteria outlined in Section 4.0 is sufficient to accomplish this. If the design criteria in Section 4.0 are employed, it is considered sufficient to eliminate injury potential for the seated occupant during turbulence. No minimum break-over force for the in-arm video is required.

5.3 Abuse Loading

Design of the in-arm video unit must consider the potential for an occupant to use the arm/monitor to assist them in entering or exiting the seat. In addition, the design must consider the potential for a passenger to fall into the arm/monitor while moving about the cabin under normal or turbulent flight conditions.

To assess the adequacy of the design to minimize injury resulting from abuse loading, ARP 5475 may be used as an accepted practice to substantiate the video arm/monitor combination pending approval by SAE. After an abuse test, the exposed fractured surfaces of the test article should be evaluated for sharp edges.

5.4 Emergency Landing Conditions

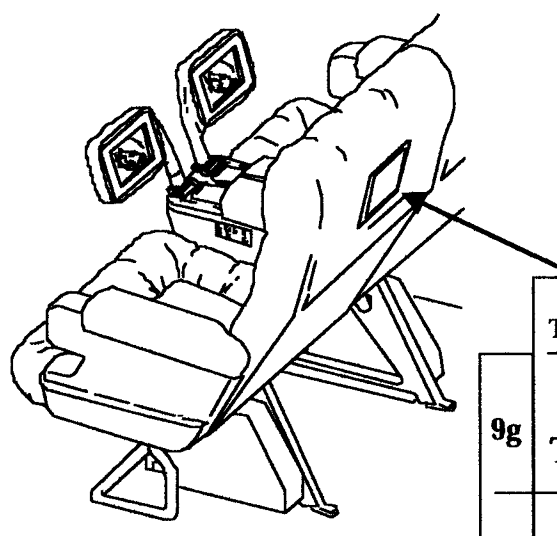
An evaluation of the in-arm video monitor shall be conducted for emergency landing conditions. This shall consist of evaluating the retention of the arm/monitor for the emergency landing loads in FAR/JAR 25.561 (and 25.562 as applicable).

In the unlikely event that the monitor/arm are exposed to head strike during takeoff, taxi and landing, a blunt trauma impact evaluation is required:

- The tests outlined in Appendix A (for aircraft without FAR/JAR 25.562(c)(5) in the certification basis)
- or a HIC test (for aircraft with FAR/JAR 25.562(c)(5) in the certification basis)..

This evaluation for emergency landing conditions does not have to be accomplished in conjunction with abuse load testing in section 5.3 above.

6.0 Certification of Seat Back Mounted Accessories



	Blunt Trauma	Post-Impact Sharp Edges	Design Standards
9g	No Test [1]	Impact Test	Industry Standards
16g	HIC Test	HIC Test	Industry Standards

(1) Impact test is required for objects greater than 3lbs

6.1 Normal Use

Seat back mounted accessories, just as all seat components, must be designed such that they do not present an injury hazard to the occupant (either seated or moving about the cabin during flight). The edge/corner design criteria outlined in Section 4.0 is sufficient to accomplish this.

6.2 Emergency Landing Conditions

An evaluation of seat back mounted accessories shall be conducted for emergency landing conditions. This includes evaluation of these accessories for both blunt trauma criteria and evaluations of seat back accessories for post-impact sharp edges.

It is understood that standard, in service aircraft seat back designs that have no accessories attached (example, telephones, video monitors, etc.) have been previously determined to be compliant with FAR 25.785. The addition of accessories to the seat back should be evaluated to ensure that passenger safety is not compromised. The two injury mechanisms outlined below should be kept in mind when considering the certification of seat back mounted accessories. In general, the decision to require a specific test should be based on engineering judgement and should be justified in the same manner, as would the decision to not require a test.

6.3 Blunt Trauma – General Discussion

Blunt trauma is incurred when the occupant's head rapidly decelerates when it strikes an object. Several factors influence the severity of blunt trauma incidents. Strike target mass and stiffness are the primary factors.

6.3.1 HIC in Certification Basis

For aircraft that have FAR/JAR 25.562(c)(5) as part of the certification basis, a row-to-row HIC test per 25.562(c)(5) is sufficient for showing compliance to the blunt trauma criteria.

6.3.2 No HIC in Certification Basis

For Pre-Amendment 25-64 aircraft, it is acceptable to show compliance to 25.785 by padding an object with one inch of energy absorbing foam. If the seat back stiffness and inertia are the dominant factor in blunt trauma impact, it is equally acceptable to demonstrate that the seat back permanently deforms at least one inch in order to be equivalent to one inch of padding. This is acceptable as a method of compliance as long as the seat back is the predominant factor in the head-strike scenario. If the total weight of the seat back mounted accessories is less than 3 pounds, 16g dynamic test data indicates that the seat back is the predominant factor Industry data indicate that standard seat back designs generally provide more than one inch of permanent deformation. Data substantiating seat back deformation is not required for seat backs unless the seat back design contains unusual features that significantly increase the stiffness of the seat back.

Using this same logic, the addition of items of mass weighing less than three pounds to a seat back are not observed to produce a significant influence on the dynamic performance of a seat. Thus these installations are judged to provide an equivalent level of safety if the installation produces one inch of permanent deformation at the top of the seat back, or in the region of the head strike.

For aircraft that do not have FAR/JAR 25.562(c)(5) as part of the certification basis, a threshold criterion of three pounds has also been determined as the basis for requiring test data for compliance substantiation.

For aircraft that do not have FAR/JAR 25.562(c)(5) as part of the certification basis, the sum total weight of the seat back accessories (items added to the seat back that are not part of the a single seat back structure or the seat back tray table design) that do not sum more than 3 pounds do not need further substantiation for the blunt trauma criteria.

Seat backs may still need to be evaluated for the general design criteria and/or the post-impact sharp edge criteria outlined in this concept paper.

Industry data indicates that standard seat back designs generally provide more than one inch of permanent deformation. Data substantiating seat back deformation is not required for seat backs unless the seat back design contains unusual features that significantly increase the stiffness of the seat back.

6.3.3 Items more than 3 pounds

For aircraft that do not have FAR/JAR 25.562(c)(5) as part of the certification basis, if the sum of seat back accessories is greater than three pounds, an evaluation must be made for the blunt trauma criteria. To accomplish this, testing shall be accomplished as outlined in Appendix A (or other method found acceptable by the appropriate regulatory agency).

Note: Appendix A provides accepted component test methods. Any new component test method should be validated against full-scale data acquired under similar conditions, prior to use as a certification tool. While linear correlation is not necessary, the component method should consistently rank impact surfaces the same way they would be ranked under full-scale conditions. The test method should be demonstrated to be repeatable, ***for the type of surface being tested.***

In addition to blunt impact, a review of the general design criteria and/or for post-impact sharp edges may be required as outlined in this concept paper.

6.4 Sharp Edges

6.4.1 Evaluation of Seat Back Accessories for Aircraft not containing FAR/JAR 25.562(c)(5) in their certification basis

Components that are mounted as seat back accessories must be designed such that their failure mechanisms upon impact will not yield sharp edges (showing compliance to FAR/JAR 25.785(k)) if the component can be struck by the head (see section 5). If an object is in the head strike zone, it should be tested using an impact test outlined in Appendix A. A component may be tested on a seat back, or independent of the seat back since it is the component that is being evaluated, not the installation. Once data is collected on one type of component, it should be readily applied to similar components if they are expected to produce similar performance.

During the impact evaluation for sharp edges, the blunt trauma criteria (e.g. HIC) does not need to be measured if this data is not required in the section above (for seat back mounted accessories less than 3 pounds).

6.4.2 Evaluation of Seat Back Accessories for aircraft that have FAR/JAR 25.562(c)(5) as part of the certification basis

Components that are mounted as seat back accessories must be designed such that their failure mechanisms upon impact will not yield sharp edges (showing compliance to FAR/JAR 25.785(k)) if the component can be struck by the head when evaluated in accordance with §25.562 (see section 5).

Appendix A

Component Test Methods

Airplanes without §25.562(c)(5) in the Certification Basis

A1.0 General Discussion for Component Testing

Component tests to demonstrate delethalization for seatbacks on airplanes that do not have § 25.562(c)(5) in their certification will generally be limited to those instances where installed items (e.g., telephones, video) exceed 3lbs, or the seatback does not provide deformation. Seatbacks with items that weight less than 3 lbs. will likely be shown to provide adequate energy absorption and airplanes with § 25.562(c)(5) in their certification basis will require compliance with HIC.

Component Testers should provide an absolute assessment of potential head injury, rather than a comparison of one surface with another. Devices such as the FMH, or Pendulum-Head testers should strike the seatback as near to perpendicular as possible.

The bowling ball test in AC 25-17 is considered an acceptable method of demonstrating compliance to section 25.785. This method accelerates an object with a mass of 13 pounds to a minimum velocity of 34 fps in order to generate an impact energy. The component test methods described below outline alternate objects to accelerate which are consistent in mass (for example, the use of an ATD head form instead of a bowling ball). They also outline alternate methods of acceleration, which yield the same minimum impact velocity (for example, the use of a pendulum or pneumatic piston instead of gravity for acceleration).

A minimum head impact velocity of 34-fps (assuming an approximate head mass of 13lbs) is an acceptable level to address the pre-amendment 25-64 case. This is the head velocity that is generated by the bowling ball test per AC 25-17 (see section 1.0 below). Under these conditions, the methods described in this appendix have been determined to measure an acceptable level of head injury protection, in accordance with the requirements of section 25.785. These methods have not been correlated with HIC as measured under full scale dynamic testing, but are considered acceptable for purposes of determining compliance to section 25.785 for airplanes that do not have section 25.562(c)(5) in their type certification basis.

Acceptable means of determining compliance is:

(a) The impact velocity must be a minimum of 34 feet per second (fps)
(b) Peak accelerations shall not exceed 200g;

(c) Accelerations in excess of 80g shall not exceed a cumulative duration of 3.0 milliseconds.

The test plan would specify the pass/fail criteria in advance of the test along with the data filtering techniques employed. In addition, it is acceptable to perform a comparative test/analysis between a seat back without accessories and the same seat back with the accessories mounted. It must be demonstrated that the seat back with the accessories has the same or lower acceleration profile as compared to the seat back without the accessories.

Although not a regulatory requirement, seatbacks are recommended to restrict break-over, which has been shown to reduce head injury potential.

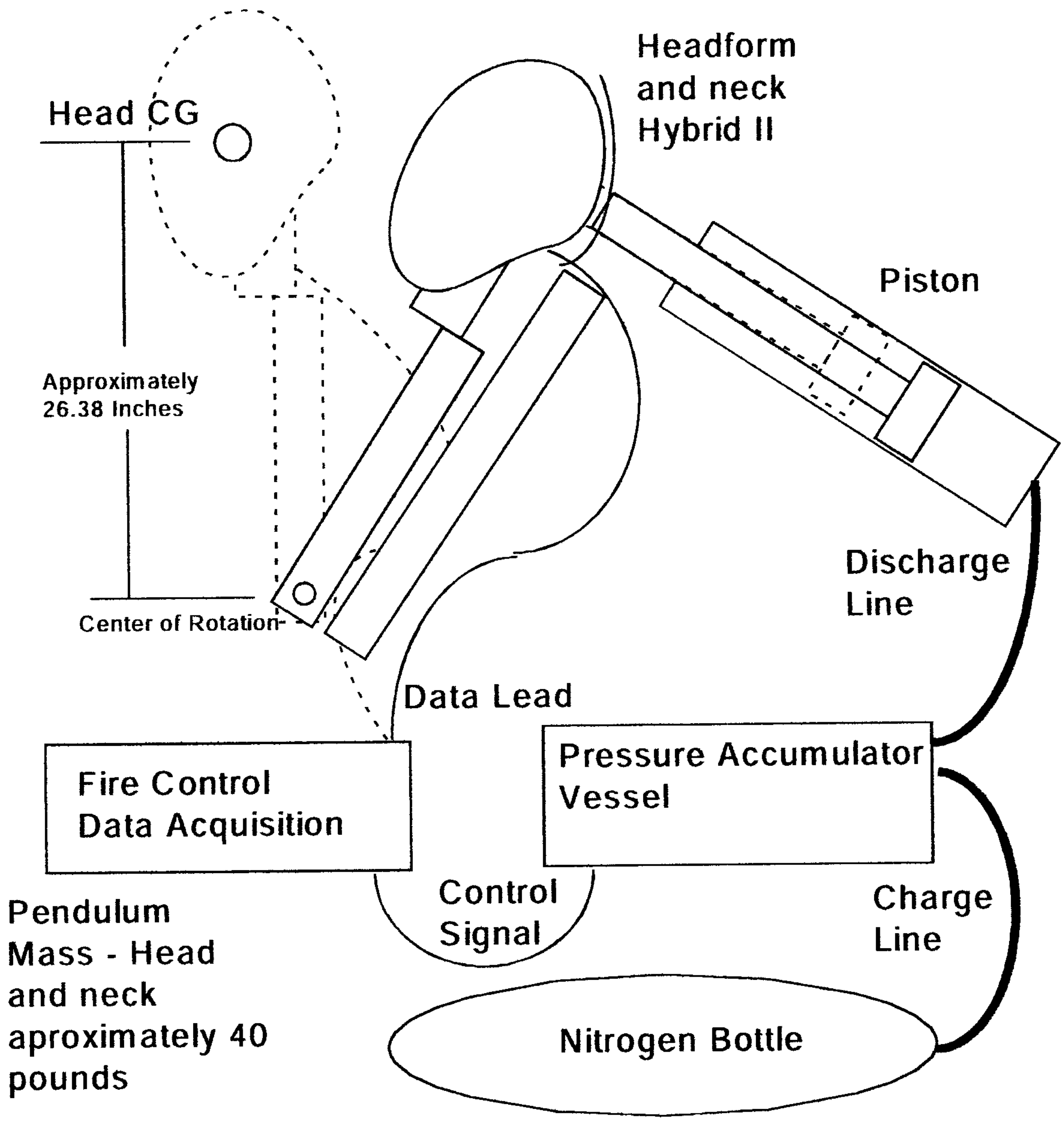
A1.0 The Bowling Ball Test

The bowling ball test as described in AC 25-17 and modified by FAA letter written 13JUL94. [Attached] (Note: the draft AC 25-17a incorporates the FAA letter 13JUL94 guidance). This test method can be used to generate an acceleration profile to be used with the pass/fail criteria noted above. It can also be used to generate rebound energy to be used as a comparison test as outlined in the FAA guidance material.

A2.0 The Head Component Tester (HCT)

The head component test device is a Hybrid II ATD head and neck mounted on a pendulum. The head/neck assembly is accelerated with a pneumatic piston to achieve the desired impact velocity. The ATD head is instrumented with an accelerometer that records the deceleration forces associated with the impact.

Schematic Diagram
Head Component Test Device



Impact velocities in excess of 40 ft/sec acheiveable

<u>Test Setup</u>

The item to assess (telephone, video screen, etc.) should be mounted in a seat back and a conveniently available seat structure that shares the appropriate mounting points for the seat back (pivot point, recline mechanism mounting) will be used to locate the seat back relative to the HCT. Note it is not necessary to represent a production seat except for the seat back and its attachment to structure.

The test setup will assure that the article is struck with the forehead of the ATD and an impact velocity of 34 ft/sec is achieved. SAE J211 compliant data accelerometer data and high-speed video for documentation are required.

Figure 1, HCT Test Setup below, is an example of the test setup, which depicts the location of the HCT center of rotation. The center of rotation is the only variable for strike orientation. Since the HCT overall arm length (pivot arm, neck and head) is less than 35", (26.38 inches), the center of rotation for the HCT cannot be placed at the seat CRP. A point along a ray between the CRP and the impact location will be used to locate the center of rotation for the HCT. This point will be 26.38" away from the terminus of the ray at the point of contact with the target. This point will insure that the ATD head will most closely mimic the intended trajectory of the occupant at the point of impact.

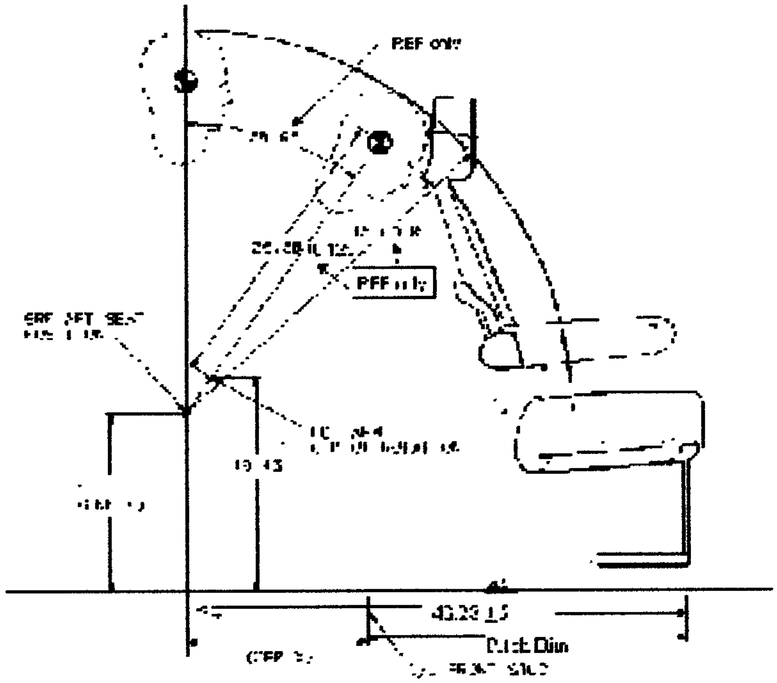


Figure 1 , HCT Test Setup

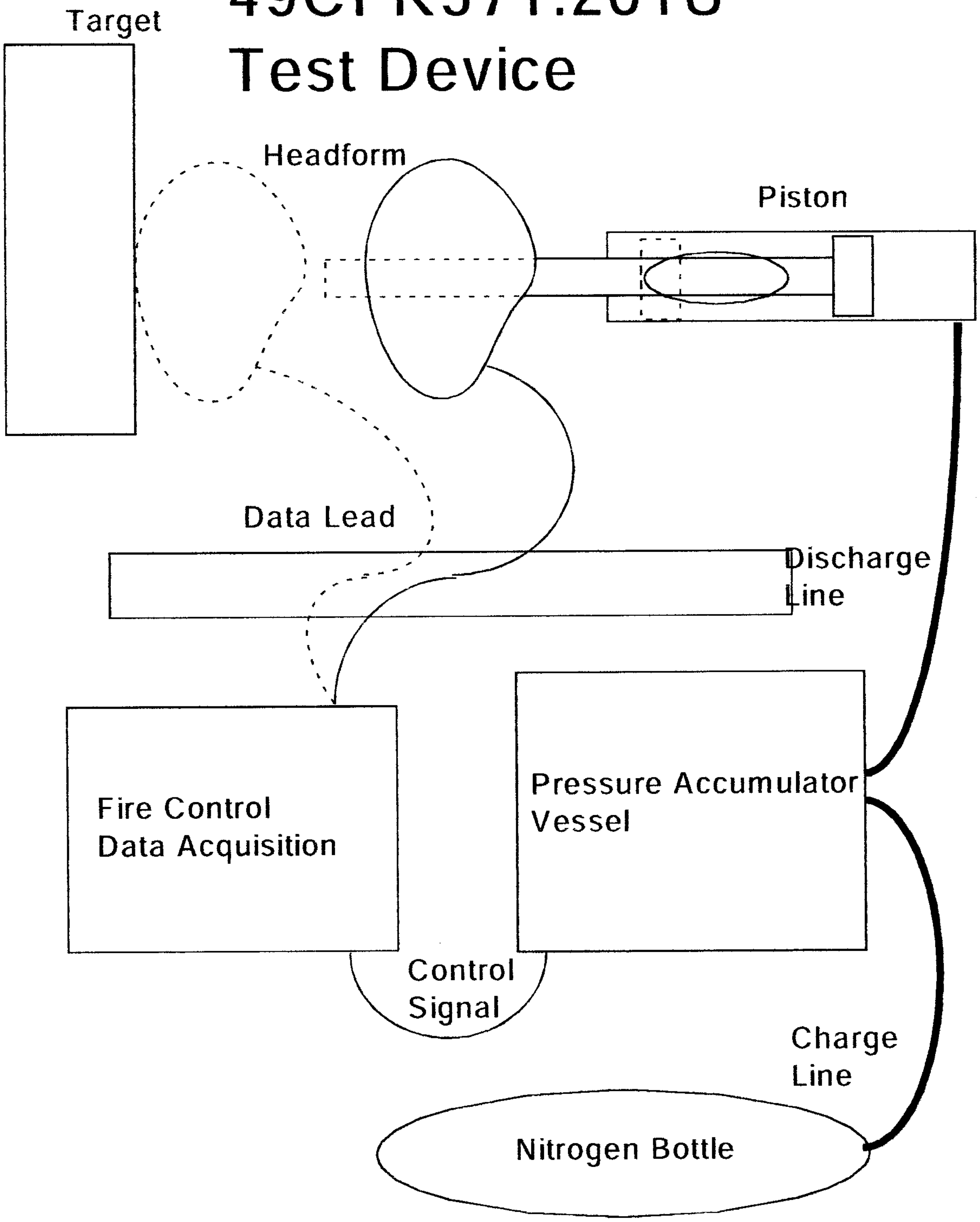
A3.0 Free-Motion Head Form (FMH)

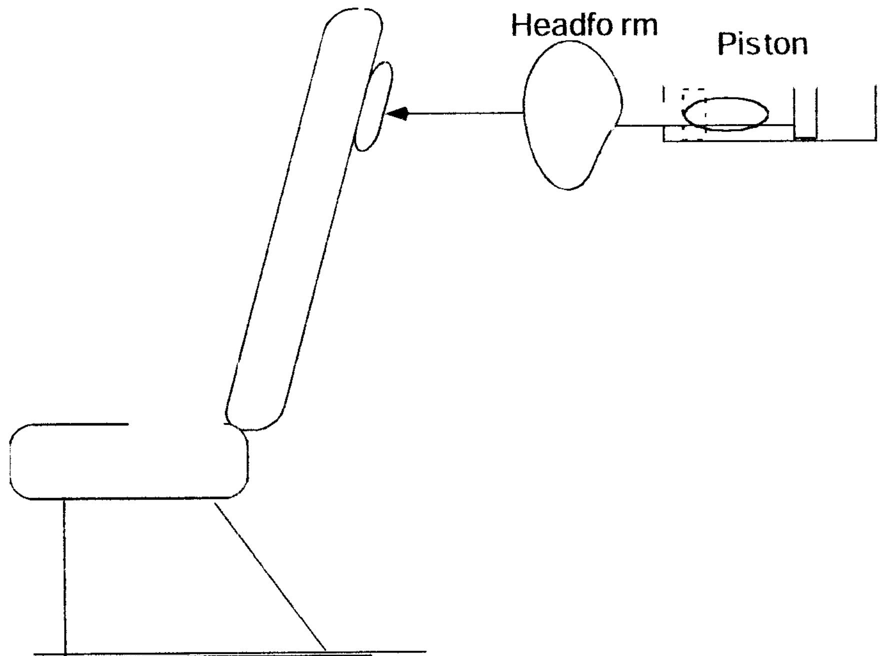
The FMH is currently used by the automotive industry to demonstrate compliance to Federal Motor Vehicle Safety Standard (FMVSS) 201U.

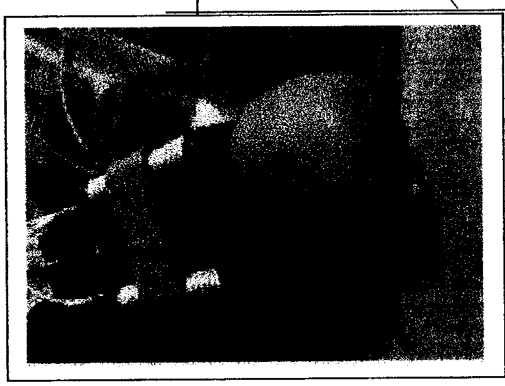
This device can be used in similar manner for FMVSS 201 for compliance to FAR25.785. The item to assess (telephone, video screen, etc.) should be mounted in a seat back and a conveniently available seat structure that shares the appropriate mounting points for the seat back (pivot point, recline mechanism mounting) will be used to locate the seat back relative to the FMH. The FMH should strike the center of the target with the forehead. Using an impact velocity of 34 feet per second, the FMH would be fired at the target horizontal to the floor. SAE J211 compliant data accelerometer data and high-speed video for documentation are required.

The figure above is an example of the test setup, which depicts the location of the FMH approaching the target horizontal to the ground.

Schematic Diagram 49CFR571.201U Test Device







Reference: National Highway and Traffic Administration report DOT HS 807 865 title: "Upper Interior Head Protection Volume I: The Development of a Research test Procedure" and "Upper Interior Head Protection, Volume II: Fleet Characterization and Countermeasure Evaluation"

A4.0 16g Test in accordance with FAR/JAR 25.562(c)(5)

A 16g forward row-to-row HIC test in accordance with FAR/JAR 25.562 (c)(5) may be performed, or similarity analysis based on full-scale test data may be completed. . A 0-degree yaw test, with the seat pitched so that there is a head strike on the component to be assessed is acceptable. The seat back and its attachment to structure must be representative to the production seat. HIC <= 1000 is the pass/fail criteria.

FAA Action – Not Available